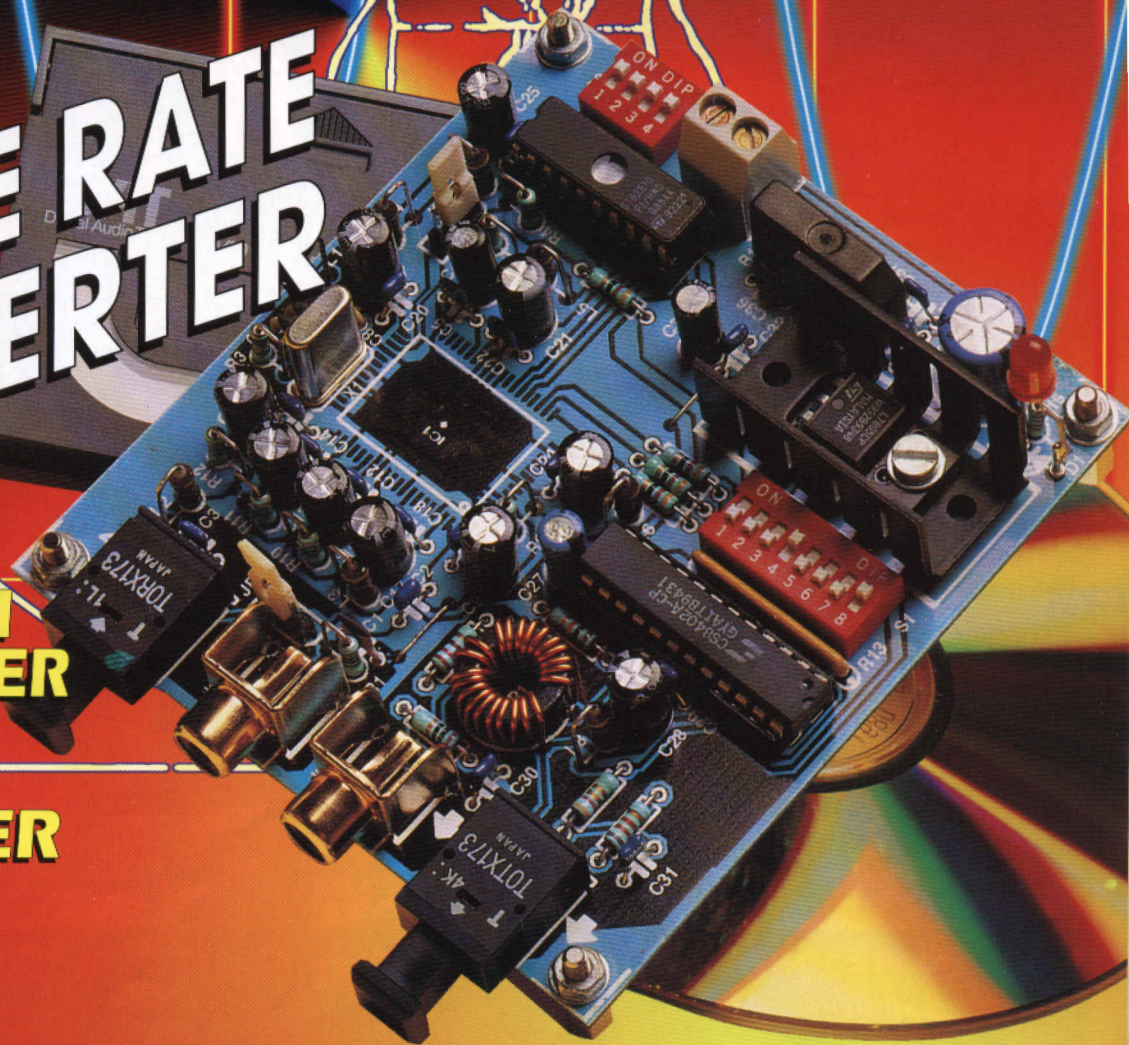# ELEKTOR
ELECTRONICS

Focus on software
for circuit simulation

SAMPLE RATE
CONVERTER

MINI FLASH
PROGRAMMER

ELECTRIC
BULB TESTER

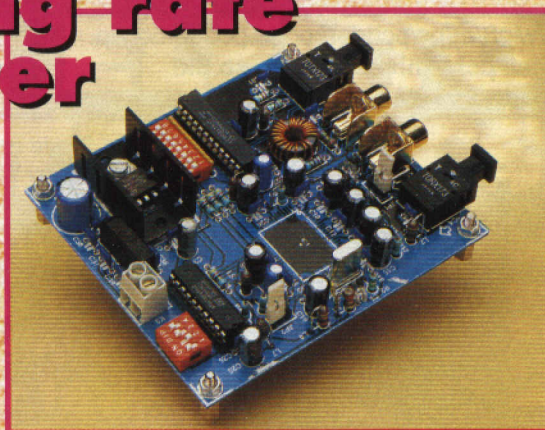# ELEKTOR ELECTRONICS

sampling rate converter

30

focus on: simulation software

56
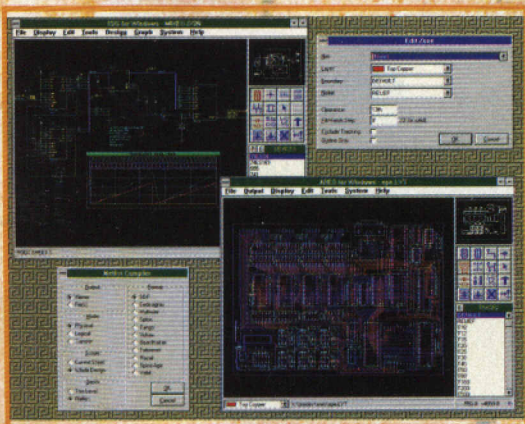
10

mini Flash programmer

52

electric-bulb tester

CONTENTS

October 1996   Volume 22

Number 248   ISSN 0268/4519

Copyright © 1996 Segment BV

A B C
AUDIT BUREAU OF CIRCULATIONS
CONSUMER PRESS

straightforward   complex

EUROPE ON THE WAY TO A STANDARD TELEPHONE CARD

While it has long been possible to use a credit card in special credit card telephones, in future the average user will be able to telephone from any major EU country using a single phone card instead of resorting to plastic credit card money. Germany and the Netherlands have taken the lead, and Switzerland and Denmark are about to follow suit. If one buys a phone card in any of these countries, it can be used in card telephones in partner countries irrespective of the local currency. British Telecom (BT) is introducing a variant. All this is made possible by the SLE443x IC from Siemens, the 'Eurochip'.

The Eurochip belongs to what is already the third generation of ICs for telephone applications. After ten years of using prepaid telephone cards, in 1995 around 270 million were sold worldwide with a value of 90 million dollars. In quantity terms, telephone cards will continue to be a strong sales sector for the rest of the decade. In just five years the market is expected to grow by more than 400 per cent to around 1.1 billion cards, worth a total of 225 million dollars.

The Eurochip has been developed specifically for use in public telephones. It is a memory chip with a 221-bit EEPROM and a 16-bit mask-programmed ROM. On the way from the Siemens chip factory to the card manufacturers, it is protected by a transportation code: only the possessor of the correct code can asses the memory – and therefore the cash it represents.

More than 20,000 units can be stored on the chip. The design of the chip and also the technology used make it impossible to tamper with the card, like, for instance, 're-charging' it after use. At the heart of the Eurochip is an authentication unit using the 'Challenge & Response' process. This protects the card against improper use. The underlying dynamic authentication system instantly generates a purely random response, which means that the device meets the most stringent security requirements.

The Eurochip's architecture permits the use, for instance, of two totally different secret keys, so that two different service providers can have access to that card. This is already a step in the direction of a multi-application card which could save considerably on costs without any penalty in terms of security. If the second key is not required, the user's abbreviated call numbers, for example, could be stored in the 64-bit EEPROM provided.

The Eurochip concept is based on a data retention time of at least 10 years and 100,000 read/write cycles for each bit. The overall performance is not currently matched by any other telephone chip in the world.

But this far from being the end of the story. Because of the convincing facilities of the Eurochip, it is on the way to becoming the international standard and is being used increasingly in other applications such as prepaid electronic purses. However, the new applications mean that new requirements are continually being placed on the ICs which cannot be met with just one device. Consequently, Siemens is developing a Eurochip family to satisfy all the requirements of the market. The second device in the family, the SLE5533, will be available by the end of the year. Its main additional facilities will be Cipher Block Chaining (of authentications) and authentication of the counter status. The range will also include low-cost variants and a rechargeable version which will become available in 1997 and 1998 respectively, thus providing a Eurochip for every application.

[965079/1-1]

PROGRESSING
FROM THE PAST

Funds have been secured from the European Union to support a multi-media project connecting major historical archives in Dorset and Ireland. The funds were granted to the DorSET Technology Centre, based at Bournemouth University and part of the Southern Science Technology Forum (SSTF).

The University's Centre for the History of Defence Electronics (CHiDE), an electronic archive of key developments in radar already accessible on the Internet, will now be linked to another major scientific archive: Ireland's Birr Scientific and Heritage Foundation. The purpose of this collaboration is to shed more light on how science, engineering and technology can progress by analysing the contribution of some major technological discoveries of the past.

In the early years of the Second World War, Dorset was the location for some of the most important developments in electronics, which helped lead to today's computer and space age. Significant breakthroughs in radar made in the country were in the forefront of the move into microelectronics which drives today's technology. Similarly in Ireland in the 1840s, the Third Earl of Rosse built the world's largest telescope on his Birr Castle estate. The Earl's youngest son, Charles Parsons, invented the steam turbine which laid the foundations for turbine technology – still one of the country's main contributions to the aerospace industry.

[965079/1-3]

NEW IGBT FROM
HARRIS

Harris Semiconductor, the company that invented the IGBT (insulated gate bipolar transistor), has developed a new generation of ultra small IGBTs that out-perform much larger power MOSFETs at much lower cost. They are the industry's first 600V IGBT family fabricated on size-1* die, which measure only 1/5th the size of conventional size-3 MOSFETs. According to Harris, the devices are the first IGBTs to challenge conventional MOSFETs in two major new applications: fractional horse-power motor control and line-voltage switch-mode power supplies.
* This measures only 74×98 mils (1.88×2.49 mm); size-3 measures 170×227 mils (4.32×5.77 mm).

[965079/1-2]

Software users – beware!

An appeals court in the USA has found that software licences – usually printed on the envelope containing the software disks or CD-ROMS and shrink-wrapped with the accompanying warning 'Read the licence before opening' – are enforceable.

Hologrammed CDs

Holograms are soon to be used in the fight against one of the biggest threats to the music, games and computer software industries: CD piracy.

The CD hologram system, called 3-D id, has been developed by Nimbus of Cwmbran, South Wales, and Applied Holographics in Newcastle.

Although hologrammed CDs cannot stop determined criminals, they will at least make it more difficult and expensive.

Sony shows CD-r drives

Almost a year after the welcome agreement between the two sides

in the battle for the standard of the DVD (digital versatile disc), Sony have exhibited their Spressa series of CD-r(ecordable) drives, both internal and external versions for the PC and Macintosh computers, reading and writing at double speed.

Internet and Yellow Pages

Next year, the Yellow Pages will include a new category: Internet providers and services. This is confirmation that Web Masters, an association of companies whose service is the creation and maintenance of pages for the World Wide Web, has been accepted by British business.

Precious books on screen

The British Library has developed a means of allowing visitors to leaf through precious books without touching them. Called 'Turning the Pages', it is a touch-sensitive screen with the open book displayed. To turn the page, you press the corner, and drag

your finger across, bringing the paper over, just as it would in reality.

First chip with 16 KB EEPROM

Siemens has taken another step towards even smaller and more powerful smart card ICs, and is the first manufacturer of these ICs to develop a chip with 16 KB of EEPROM. The chip, designated SLE44C160S, is part of a new controller family and requires less than 15 mm² of space. In addition to the 16 KB of EEPROM, it offers 15 KB of ROM and 256 bytes of RAM. Its speed is evidenced by the fact the the EEPROM can be programmed with 64 bytes in 3.5 ms.

The SLE44C160S is the flagship of the new controller family with even better security functions. These include additional barriers against potential hackers, special protective functions for the EEPROM cells, encryption of the ROM addresses, and measures to prevent simulation of the smart card ICs.

mini flash programmer

for Atmel 89C1051 and 89C2051 controllers

For not too extensive switching and control applications, micro-controllers with relatively few I/O lines, a limited instruction set and almost no peripherals are far better suited than power boxes like, say, the 8051 with 40 or more pins. Examples of small microcontrollers are RISC (Reduced Instruction Set Computer) processors such as the well-known PICs from Arizona Microchip, the devices in the ST6 family from Thomson, and, recently, the two 8051 compatible Flash controllers type 89C1051 and 89C2051 from Atmel. For the latter devices we describe a programmer with the perfect balance: simple hardware and powerful software.

Design by D. Laues
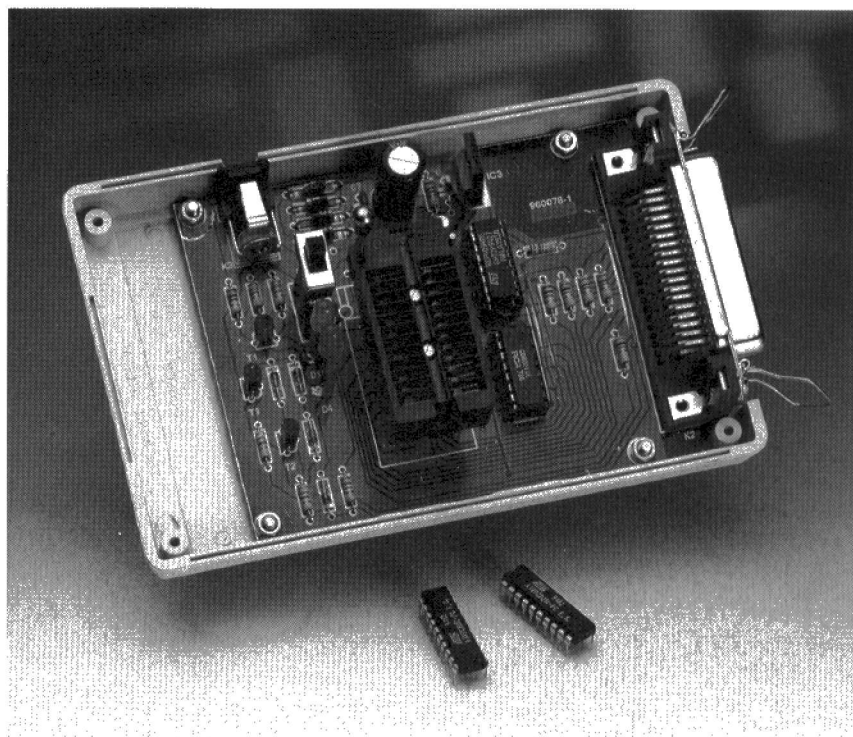
As regards internal architecture and instruction set, the 89C1051 and 89C2051 are compatible with Intel's industry-standard 80C51. As indicated by the overview of their main properties in **Table 1**, the Atmel processors are actually miniature versions of the 8051 with reduced ROM and RAM ranges. As regards computing power and application range, the Atmel chips are about equivalent to the PIC microcontrollers from Arizona Microchip. The 89C1051 and '2051 do, however, have some distinct advantages:

✗ *software compatible with the industry standard 8051*, allowing you to continue using your favourite assemblers and simulators. Also, you do not have to learn a new programming language!
✗ *Flash technology*, so throw away your piggy-backs, EPROMs, UV erasers and expensive OTPs. The Atmel controllers are re-usable all the time.
✗ *Inexpensive*. UV-erasable PICs are much more costly!

So far, the 89C1051/2051 have not reached wide publicity despite their advantages. Although the Flash programmer we published in the May 1995 issue of *Elektor Electronics* was capable of programming the 89C2051, the hardware was fairly extensive. This article not only provides additional information on this controller type, it also presents a low-cost programmer for both the 89C1051 and the 89C2051.

SPECIAL FEATURES OF THE 89Cx051

Extensive information on the 8051 family appeared in various articles in *Elektor Electronics* over the past few years, so that it is not necessary to revert to this subject in the present article.

Two properties of the hardware contained in the Atmel controllers are so unusual, however, that they deserve special attention. These properties, when used in a clever way, can help to simplify the circuit design considerably.

Direct LED drive

Ports P1 and P3 are current-boosted and capable of sinking 20 mA to ground. That enables LEDs, opto-isolators, small relays and similar devices to be controlled directly from the chip.

Integrated comparator

Alternatively, pins P1.0 and P1.1 may be employed as analogue inputs (P1.0 = non-inverting, P1.1 = inverting) of an on-chip comparator. The comparator compares the voltages at these inputs. If the difference is positive, the comparator output is switched high, when the difference is negative, the output is pulled low. This information is read via the (internal!) P3.6 port line. The solution with the comparator makes it easy to detect when an analogue voltage exceeds a certain threshold level. Using the on-chip comparator, all you need to realise a simple A-D converter is an additional R-C network and some software. The input voltages applied to the chip may lie between 0 V and V_{cc}.

BRAINS, NOT MUSCLES

The mini Flash programmer of which the circuit diagram is shown in **Figure 2** is proof that a modest hardware setup is sufficient if you are able to fully exploit the possibilities of a PC. Because the control software is very powerful indeed, only a handful of com-

Figure 1. Internal structure of Flash controllers 89C1051 and 2051 with analogue comparator.

ponents is required to do the job. The programmer is powered by an ordinary mains adaptor supplying an output voltage of at least 12 V a.c. or d.c. A 7805 on the programmer board then provides a stable supply voltage for
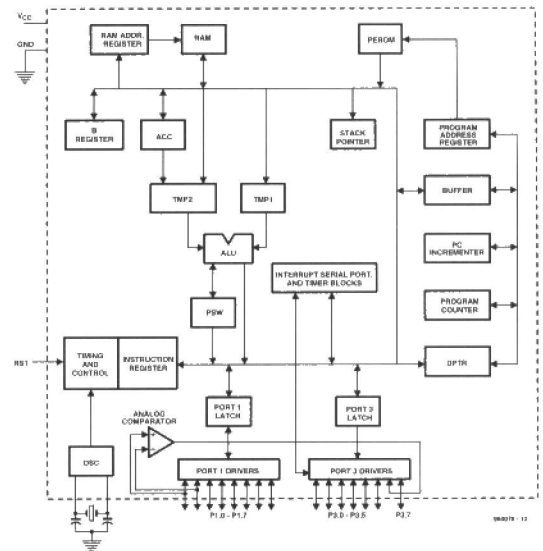
Figure 2. The simple hardware of the 89C1051/2051 Flash Programmer. Before starting the programmer, always make sure to have controller pin 1 aligned with ZIF socket slot 1.
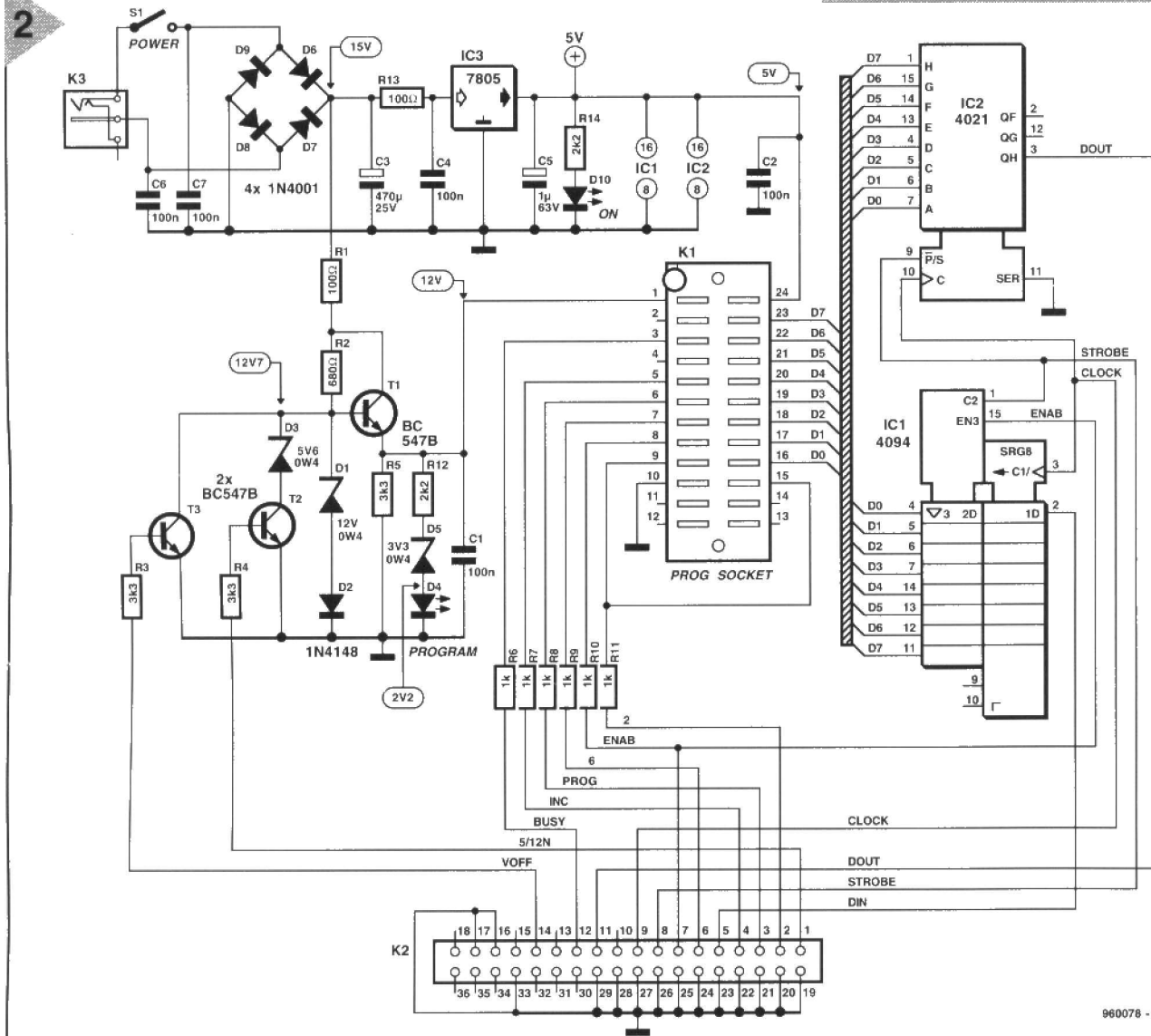
Table 1. Main features of Atmel controllers

	89C1051	89C2051
ROM	1 kByte	2 kByte
RAM	64 Byte	128 Byte
Timer	1	2
Serial interface	-	1
Interrupt sources	3	5
Supply voltage:	2.7 - 6 V	
Ports:	15	
Case:	DIL / SO 20 Pin	
Manufacturer:	ATMEL	
Clock frequency:	0 - 24 MHz	
Program memory:	Flash (>> 1000 programming cycles)	
Further features:	analogue comparator	
	20-mA ports for direct LED drive	

Table 2. Operating modes of 89Cx051

Mode		RST	P3.2*	P3.3	P3.4	P3.5	P3.7
Write Code Data		12 V	#	L	H	H	H
Read Code Data		H	H	L	L	H	H
Write Lock	Bit -1	12 V	#	H	H	H	H
	Bit -2	12 V	#	H	H	L	L
Chip Erase		12 V	#	H	L	L	L
Read Signature Byte		H	H	L	L	L	L

*: P3.2 = $\overline{PROG}$

the ICs. LED D10 acts as a 'power-on' indicator.

Transistors T1, T2 and T3 form and adjustable voltage source. When T3 is driven, the base of T1 is at 0 V, and the programming voltage is switched off. When only T2 is driven, zener diode D3 stabilizes the base of T1 at a level of 5.6 V, so that a programming voltage, V_{pp}, of 5 V is obtained. When T2 and T3 are switched off, diodes D1 and D2 provide a reference voltage of 12.7 V, so that the second programming voltage of 12 V is obtained. Resistor R1 limits the current to the controller's programming pin. When the 12-V voltage is actuated, diode D5 conducts also, and the **Program** LED lights.

The data traffic is arranged by two shift registers type 4021 and 4094. In programming mode, the data are first

serially written from the Centronics interface to the 4094. After the enable signal, this data is available via controller port 1 at outputs Q1 through Q8. The read operation (from the Atmel controller in the direction of the PC) is exactly the other way around, this time via the 4021. The data are copied as parallel words by the controller, and sent to the PC as serial words via the **DOUT** line.

All other data and control lines of the Centronics interface control the different modes of the programmer, coordinate the shift registers and the voltage selection. You need not worry about the exact programming timing, because the actual programming operation is controlled by the chip itself. All the software does in this respect is monitor the **BUSY** signal which is used by the chip to flag that a byte has

an EEPROM, not a Flash type). The available modes are listed in **Table 2**.

SOFTWARE

The control software written for this project runs under DOS and enables all functions for reading as well as programming of the 89C1051 and 89C2051, including setting the lock bit (**Table 3**). When the program is started, the hardware is prompted to run a self-diagnostic test. In most cases, existing assembly language programs may be adapted without problems. This is done as follows:
- check the required ROM and RAM size;
- restrict I/O instructions to Ports 1 and 3 (not P3.6!);
- check the special function register (Table 5).

Programs which are produced from scratch and intended to run on the Atmel chips may be written with the aid of an ordinary 8051 assembler. Do, however, observe the above restrictions. If you use a table-oriented assembler like TASM, it may be necessary to mask out the registers and ports which are not allowed. All data for the programmer must be in **binary** form.

CONSTRUCTION AND PRACTICAL USE

The single-sided printed circuit board shown in **Figure 3** is populated with regular-sized components. Building up the board, we feel, should not cause problems. The LEDs, S1 and the programming socket are fitted at some distance above the board, using pieces of component wire or stacked IC sockets. The board should be fitted as low as possible in the case. The programming socket is a 24-pin ZIF (Zero Insertion Force) version with wide slots (20-pin ZIF sockets being few and far between) to accommodate the 0.3-inch wide Atmel ICs. Next to the ZIF socket you have to fit seven wire links, and one near the Centronics connector. There are no adjustment points in the circuit.

After you have checked your construction work, connect the output of the mains adapter to the socket on the board, and switch on S1. LED D10 should light. Check that a voltage between 15 V and 16 V is present across capacitor C3. The supply voltage for all ICs behind the voltage regulator should be a steady 5 V. Next, it is recommended to run an extra check on the programming voltages at pin 1 of the ZIF socket, for all three modes of operation (**Table 4**). To do so, connect the indicated voltages to control lines 'Voff' and '5/$\overline{12}$', and check that the relevant programming voltage actually

Table 3. Lock bit function

Program Lock Bits		Protection Type
LB1	LB2	
U	P	No program lock features
P	U	Further programming of Flash disabled
P	P	Further programming of Flash and Verify disabled

Lock bits may only be cleared while the chip is being erased.

been programmed.

You will also look in vain for an addressing circuit around the 89Cx051. An internal address counter is cleared to zero after a reset (i.e., automatically at the start of the program), and incremented after each byte. Consequently, any program should always be loaded *completely*, i.e., from the start. Post-editing of a single byte is not possible (else, the device would have been

Table 4. Program voltage control/selection

Line		U_{prog}
Voff	5/$\overline{12}$	
+5 V	+5 V	0 V
+5 V	GND	0 V
GND	+5 V	+4.75 - 5.25 V
GND	GND	+11.5 - 12.5 V

reaches the ZIF socket. The latter value is particularly important, because the controller may be damaged if it is exceeded. Next, the programmer is connected to the LPT1 or LPT2 port on the PC, and the software is launched.

The mini Flash programmer was designed to be an inexpensive, simple programmer and not intended to intercept gross operating and user errors. Because of this, keep the following in mind if you want to ensure a long lifetime for your Flash controllers:

A controller may only be inserted into the socket, or removed, if:
- the mains adaptor is plugged in;
- the programmer is connected to the PC;
- the associated software has been launched;
- the supply voltage has been switched off with S1.

When inserting a controller, make sure that pin 1 of the IC goes to slot 1 of the ZIF socket.

Figure 3. The printed circuit board for the programmer is relatively small and single-sided.

Also, never switch on S1 with a controller installed in the ZIF socket, and with the program not active. This is necessary to make sure that all the necessary logic levels are properly available when a controller is inserted or removed.

FAULTFINDING

A short self-diagnostic test is run when the program is launched. Two bytes, $0AA_H$ and 055_H, are written serially and read back again. When the test is finished without problems, the two CMOS ICs and the power supply may safely be assumed to function properly. Current consumption will be between 25 and 30 mA, and about 5 mA more when a controller is fitted in the ZIF socket.

When the self-diagnostic test fails, you should first check whether the supply voltage is present (the green LED should light), and the Centronics link is all right both as regards hardware and software. The program is launched again after selecting the right Centronics port. All user settings are stored safely in a configuration file.

To check the proper operation of the Centronics interface, launch the program again, and select the option 'Program'. Enter any filename you like, and use an oscilloscope to check that clock pulses appear at pin 3 of IC1. Take a good look at the signal levels: a logic low should be lower than 0.8 V, a logic one, higher than 3 V. This also applies to the other Centronics connections. The inputs are the most critical in this respect. There are Centron-

ics cards around with very low-value pull-up resistors (e.g., 1 kΩ) on the input lines. Such a line can not be
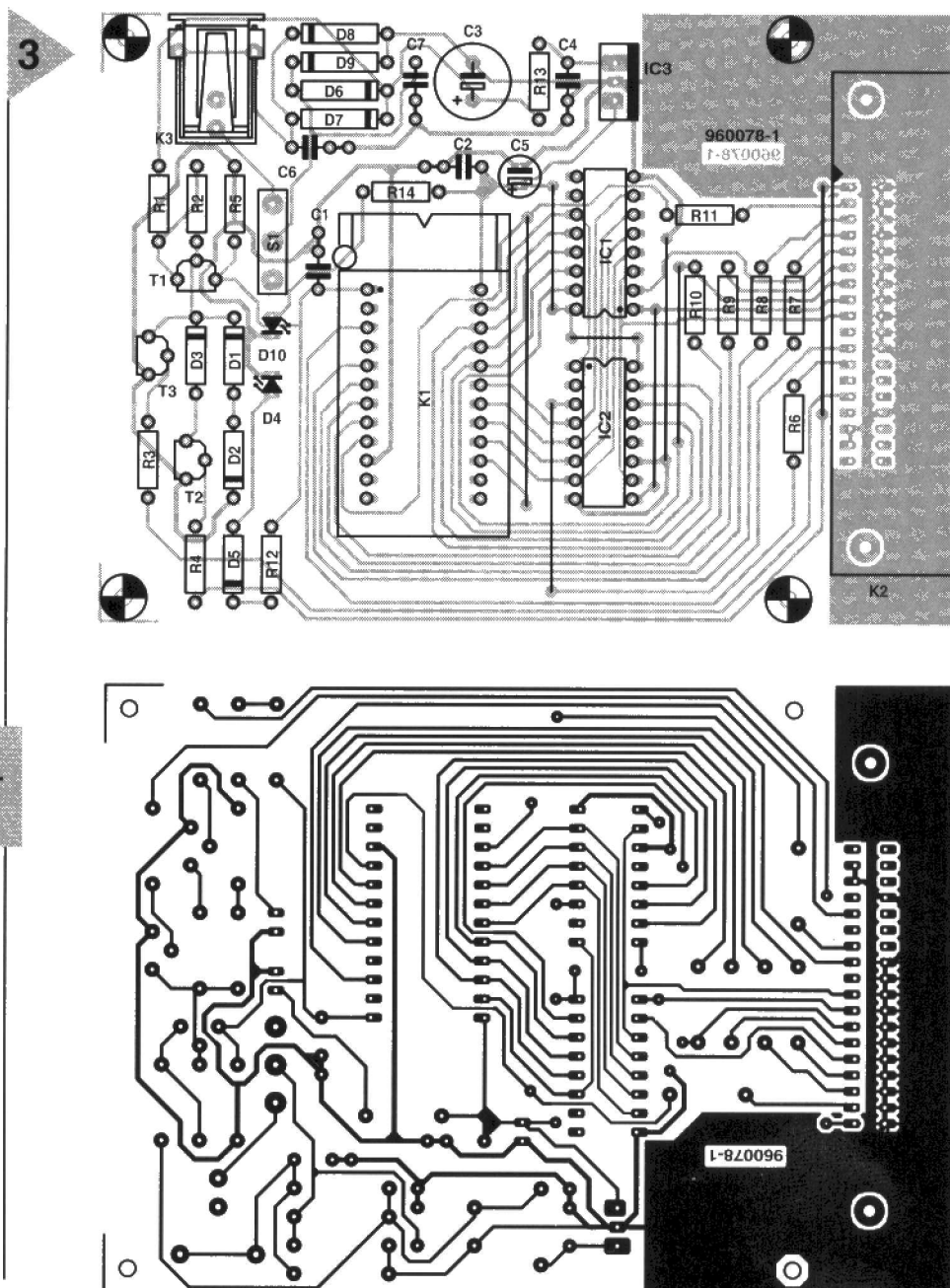
pulled down sufficiently low by pin 3 of IC2. The same goes for lines which have a 1-kΩ protection resistor. The

COMPONENTS LIST	D6-D9 = 1N4001
	D10 = LED, green
Resistors:	T1;T2;T3 = BC547B
R1;R13 = 100Ω	IC1 = 4094
R2 = 680Ω	IC2 = 4021
R3;R4;R5 = 3kΩ3	IC3 = 7805
R6-R11 = 1kΩ	
R12;R14 = 2kΩ2	**Miscellaneous:**
	K1 = 20-pin or 24-pin ZIF socket, wide
Capacitors:	slots, for 0.3-in. wide DIL ICs (e.g.
C1;C2;C4;C6;C7 = 100nF	Aries)
C3 = 470µF 25V radial	K2 = 36-pin Centronics socket, angled
C5 = 1µF 63V radial	pins, PCB mount
	K3 = Mains adaptor socket, PCB
Semiconductors:	mount
D1 = 12V 400mW zener diode	Enclosure: Pactec, size 145x92x28mm
D2 = 1N4148	Printed circuit board and software on
D3 = 5V6 400mW zener diode	disk: order code 960078-C. Software
D4 = LED, red	also available separately: order code
D5 = 3V3 400mW zener diode	966015-1.

4

MINI FLASH MICROCONTROLLER PROGRAMMER

POWER ON PROGRAM
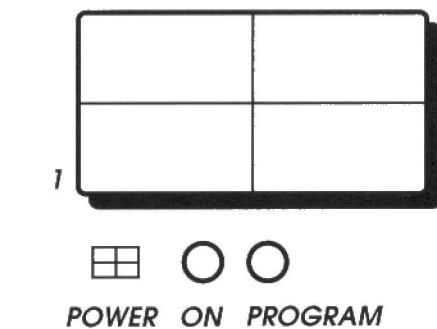
960078-F

Figure 4. Suggested design for a front panel.

problem is easily solved, however: replace the 1-kΩ resistors by 10-kΩ types, or replace the entire I/O card with a more up-to-date one.

Also check that you are going through the programming sequence in the right order: connect everything, switch on programmer with S1, start program, switch off programmer, insert controller, switch on programmer again, and download the file. Because the last phase of the programming sequence is a verify routine, the **Program LED** lights dimly after programming. It goes out, however, if you leave the menu by pressing the Esc (escape) key. Next, you switch off the voltage with S1 and remove the programmed controller from its socket.

(960078)

Is there really nothing new under the sun and does history repeat itself? You don't really want to believe that, but sometimes you wonder as in the case of the network computer (NC) recently announced as 'new' by the American company Oracle. Now, all this 'new' computer does is to shift the emphasis away from the desktop to the network. This at once reminds you of the slogan of another American company, Sun, first used in the late 1980s, that "the network is the computer". In those days, it was difficult to realize – now, with the Internet blooming, it can become reality.

In essence, the NC represents a technology, based on a 1980s design by Britain's Acorn, which has been trying to be accepted for almost ten years.

In the same way, Java, the language of the Internet, is based on a language originally designed for interactive tv set-top boxes – a market that has all but collapsed.

It stands to reason that, although Microsoft belittles the concept of Oracle's $500 NC, sooner or later there is bound to be a clash between the old and the new. Nevertheless, whatever the fortunes (or misfortunes) of the NC, the Internet will not replace the PC, at least not in the foreseeable future.

Having said that, it must be admitted that the PC market is becoming boring owing to lack of novelty – it is now just a market with all interest focused on price and quality, rather than on technical facilities.

The move from desktop to network is, of course, a matter not of hardware, but of software, that strange, intangible commodity consisting of bits. These bits – ones and zeros – are by themselves inactive, just like our genetic code, and only come to life when they are placed in the right receptacle. Whether that receptacle is a computer or a network does not matter. What does matter is the realization that a computer exists merely to bring software to life – and this task can also be fulfilled by a network such as the Internet. But let us not believe that we're talking of a new technolgy.

[LS – 965098]
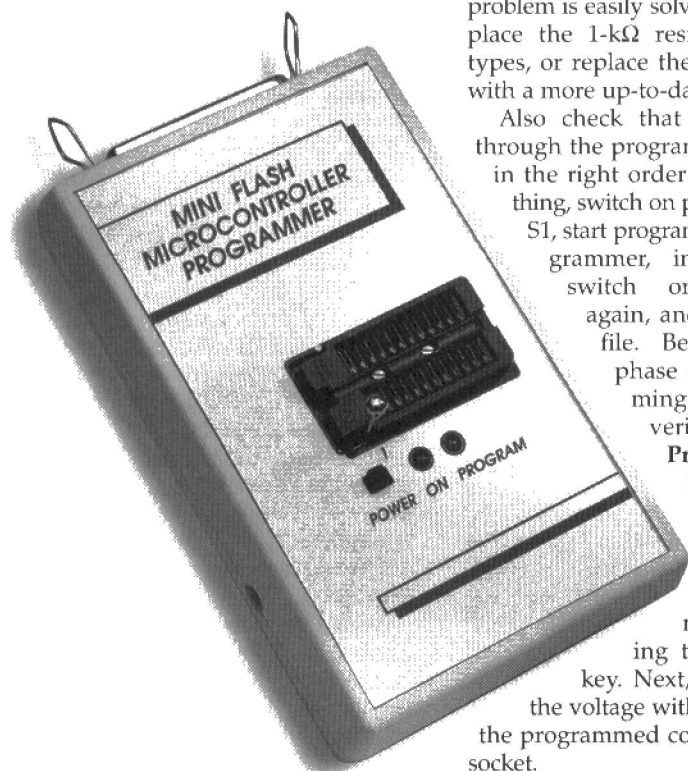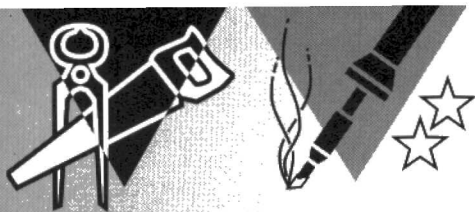
The earth hides many treasures from its inhabitants. Sometimes precious material is buried deep in the earth's crust, and can be detected with pretty sophisticated measurement systems only. However, small metal objects which are close to the surface may be located fairly easily using simple equipment. A day's hunting on the beach, for example, using the present metal detector may yield some unexpected finds.

a one-IC coin hunter

mini metal detector

In our experience, metal detectors have always had a very special appeal to many readers. That is not difficult to explain, because few things are more exciting than the question 'is there a valuable object just below the earth's surface?'. Many amateurs will, for example, not want to miss the opportunity to scan an area for lost coins, where a large crowd has gathered. Metal detectors are also used professionally. Mine fields, for example, are minutely examined for buried

Design by Z. Kaszta

explosives with the aid of advanced detectors.

Obviously, the requirements for a metal detector are dependent on the application. Most hobbyists will not need a complex, costly and extremely sensitive detector. That is why we present a metal detector which boasts simplicity. From practical experiments, we know that the present detector is capable of locating metal objects which are buried up to 15 cm below the surface. That means that the instrument, despite its simplicity, is suitable for scanning a lawn, a gravel path or a beach for lost metal objects. Those of you who are keen on experimenting will find the circuit very rewarding to build and try out. Because of its simple setup, the circuit has a number of inherent limitations which make it less suitable for professional use.

TREASURE HUNTING

Basically, two effects from elementary physics are employed to detect metal objects buried in the soil.

Firstly, a metal object changes the self-inductance of a coil and, if applicable, the degree of coupling between two coils. The effect may be positive or negative. The property of the materials which plays an important role in these effects is called *relative permeability* (μ_r). A distinction is made between paramagnetic materials ($\mu_r > 1$), diamagnetic materials ($\mu_r < 1$) and ferromagnetic materials ($\mu_r >> 1$). Although it is fairly difficult to tell exactly which material is being detected just on the basis of the μ_r property, it is definitely possible to tell apart ferromagnetic materials on the one hand from paramagnetic or diamagnetic materials, on the other.

The second effect employed in the detection of metal objects is based on eddy currents which are generated when a conductor is subject to a varying magnetic field. The level of the eddy currents is determined by the size and the shape of the conducting object, as well as by the resistivity of the material. Strong eddy currents may be induced in, say, a large sheet of metal, while they are much reduced if slots are cut in the same sheet. Finally, the level of the eddy currents is also determined by the position of the object in the magnetic field, and, as a result, by the number of field lines that cross the object.

We also have to take into account the distance of the object to the search head which contains the detection coil, and the effect of the soil. All in all, it will be clear that it is virtually impossible to obtain a reliable material indication on the basis of just one detection method.

BASIC CIRCUITS

In practical circuits of metal detectors, you may come across three different types of detection technique. Each if these is briefly discussed below.

BFO (beat frequency oscillator). In this system, a signal with a variable frequency is mixed with another signal having a fixed frequency. The difference (or 'beat') frequency produced by the mixer is in the audible range. If the search head comes close to a metal object, the oscillator producing the variable frequency is de-tuned, resulting in a different tone which the user hears via a loudspeaker.

TR/IB (transmit-receive/induction balance). As indicated by the name, this method utilizes a transmitter as well as a receiver. If a metal object comes within the scan range of the search head, the degree of magnetic coupling between the inductors is modified. This change, in turn, produces a change in the oscillator output signal level.

PI (pulse induction). In this system pulses are generated and transmitted. The intensity and the shape of the received pulses provide an indication about the presence of metal objects within the scan range.

Each of the three detection methods has its own advantages and disadvantages. The ideal metal detector would, therefore, have to be a combination of all three detection methods. Unfortunately, that would result in a fairly complex circuit.

A SIMPLE APPROACH

The circuit diagram of the metal detector we have in mind is shown in **Figure 1**. A detection method is applied which bears great resemblance to the above mentioned BFO principle. In this case, however, the mixer output signal is not an audible frequency but a current which is used to drive a moving coil meter directly.

Looking at the circuit diagram you will probably agree that it is difficult to think of a metal detector design with fewer components than shown here. Just one 4030, a moving coil meter and a handful of passive parts are assumed to do the job. The total cost of this project should remain well below £10 or so. The circuit utilizes two LC oscillators, built around IC1a and IC1c, which are coupled to some extent via capacitor C7. The oscillator built around IC1a operates at a fixed frequency of about 300 kHz. Normally, the oscillator around IC1c produces the same frequency, but that is no longer so when the self-inductance of L2 is changed by a nearby metal object. Gate IC1d provides an XOR function and combines (actually, multiplies)

the oscillator output signals. Assuming that no metal object is detected, the capacitive coupling between the two oscillators maintains a fixed phase difference of 90°. Consequently pin 11 of IC1d supplies a square wave with a double frequency (approx. 600 kHz) and a duty factor of about 0.5. Gate IC1b acts as an inverter with meter M1 connected between its input and output. Preset P1 serves to set the meter sensitivity.

The circuit is powered by a single 9-volt battery. Under normal conditions, the battery will last for quite a few hours of treasure hunting.

Capacitor C9 provides sufficient supply decoupling, while diode D1 pulls the emergency brake when the battery voltage is connected the wrong way around.

Figure 2. The printed circuit board for the metal detector is simple and compact. If the board is mounted at some distance from coil L2, capacitors C4, C5 and C6 have to be mounted directly on to the coil.

Figure 1. Circuit diagram of the ultra-simple metal detector. L2 is the search coil which you use to hunt for buried metal objects.

CONSTRUCTION AND TEST

The printed circuit board designed for the metal detector allows a pretty compact construction (**Figure 2**). With the exception of coil L2, there are no critical components, so that building up the circuit board will not present

---
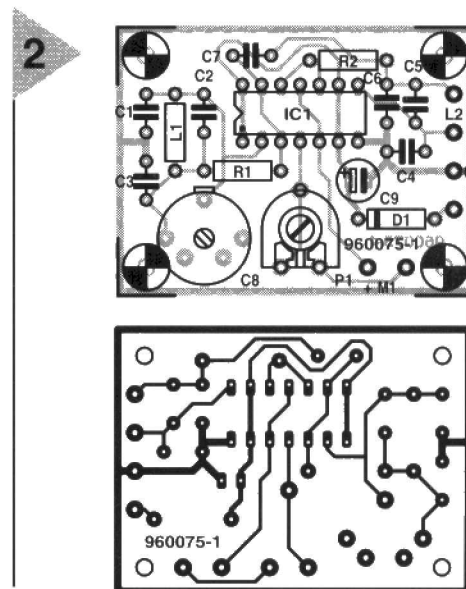
COMPONENTS LIST

Resistors:
R1,R2 = 22kΩ
P1 = 10kΩ preset H

Capacitors:
C1,C3,C4,C6 = 680pF
C2 = 220pF
C5 = 270pF
C7 = 3pF3
C8 = 100pF trimmer
C9 = 10μF 63V radial

Inductors:
L1 = 330μH
L2 = home made search coil, see text

Semiconductors:
D1 = BAT85
IC1 = 4030

Miscellaneous:
M1 = moving coil meter, 100μA
Printed circuit board, order code
960075-1 (see Readers Services page)

undue problems. Simply solder each part on to the board at the position indicated by the component overlay (printed on the board). Turn the wiper of P1 to the extreme counter-clockwise position (minimum sensitivity).

The design is based on a simple air-cored coil with a diameter of about 7.5 cm (3 inch), and about 40 turns of enamelled copper wire or 25 turns on a diameter of 200 mm. The coil former is a small piece cut from a cardboard or solid plastic (PVC) tube. Alternatively, you may use a sealing cap for 3-inch dia. PVC drainage tubing as a former for the coil. The larger the coil diameter, the higher the sensitivity of the metal detector. Inductor L1 is a ready-made type.

If it has an adjustable core, trimmer C8 may be omitted. The circuit is then

Figure 3. This search coil was used for the prototype.

Table 1.
Some materials and their magnetic properties.

Diamagnetic	Paramagnetic	Ferromagnetic
bismuth	aluminium	cobalt
glass	silicon	nickel
copper	air	iron
water	platinum	ferroxcube
silver	palladium	steel

adjusted with the aid of the core. If the circuit is not sufficiently sensitive in practice, the value of resistor R2 may be increased a little.

Adjusting the completed circuit is quite simple. Switch on the detector, and adjust trimmer C8 until the meter needle swings from the right to the left. Obviously, no metal objects should be in the vicinity of L2 during this adjustment. The correct setting of the trimmer is found when the needle remains steady at the start of the scale. You may want to turn the preset into an external control, so that the sensitivity of the detector may be adapted during actual use of the detector.

Unfortunately, one drawback of the simplicity of the circuit is that its set-ting is affected to some extent by ambient temperature. If instability turns out to be a problem, it is recommended to fit coil L2 and capacitors C4, C5 and C6 close together so that they are always at the same temperature. So, if the circuit is mounted at some distance from the search coil, the capacitors are fitted close to the coil instead of on the board. The stability may also be improved by covering the search coil, for example, by moulding it in a resin compound, or covering it with self-amalgamating tape.

With ergonomics in mind, the (moulded) search coil is best mounted on a stick. The moving coil meter is then fitted in a small case which is secured close to the handle.

The prototype was fitted in an assembly consisting of PVC drainage tubing and coupling parts which should be available from most DIY stores. The 'stick' is formed by a tube with a diameter of about 32 mm (1¼in). The tap for the meter is made from a T-piece. The case containing the meter is fitted on to the T piece. The search head is a sealing cap, here, a 200-mm dia. type is used. The junction between the search head and the 'stick' consists of a knee piece having an angle of 135°. A cap is glued on the top end of the 'stick'. The windings of the search coil may be secured at the outside of the search head, and then covered with insulating tape or similar for protection.

The photograph of the prototype gives a good impression of a suitable construction. The total cost of the instrument will be, well, modest!

START HUNTING
Having finished the adjustment of the completed instrument you are ready to start treasure hunting. Before you dash out of doors, however, some experiments will be required to get the 'feel' of the detector. In practice, diamagnetic and paramagnetic materials will have a very small effect on the self-inductance of the search coil. Ferromagnetic materials, on the other hand, produce a marked increase in the self-inductance. However, because of the size of the objects you will want to discover (coins, i.e., usually sheet material) and the high oscillator frequency, eddy current losses are an important factor in all categories. These eddy current losses lower the oscillator frequency of the search circuit. Because the eddy current change is the most important factor, the meter on this metal detector will swing in the same direction for all detected materials. If the needle starts to move while you swing the search head over the ground, a diamagnetic or ferromagnetic object is detected within the scan area. Time for further investigations!

(960075)

thrifty
crystal oven

for high frequency stability

Design by F. Hueber

It is well known that the frequency of a crystal oscillator depends to some degree on the ambient temperature. Although this is often of no consequence, there are cases when the frequency is needed as a standard and any deviation from its true value is not acceptable. For instance, the crystal oscillator in most frequency meters and in many signal generators is fitted in an oven that keeps the crystal temperature at a stable value.

The temperature at which the crystal is held must at all times be higher than the sum of the ambient temperature and the self-temperature of the equipment in which the crystal is contained. Assuming a top ambient temperature of 30 °C, it is unlikely that the thermostat needs to be rated higher than 50 °C.

The idea of using a power transistor as the heating element is not new. This works in conjunction with a resistor with negative temperature coefficient (NTC) or a silicon sensor acting as the sense element. The output of this element drives the heating transistor via a control circuit and thus influences its dissipation. The difficulty of using this setup in a home-constructed equipment is obtaining good thermal coupling between the heating transistor and the sensor, which is, of course, essential for accurate and fast control of the temperature.

The circuit proposed in this article is based on a different approach. In it, the base-emitter voltage of the heating transistor is used as the control voltage, so that a temperature sensing element is not required. It is known that this voltage in case of a p-n junction through which a constant current flows varies at a rate of -2.2 mV K^{-1}. Such a voltage applied to an evaluation circuit is very suitable to assume control of the dissipation in the heating transistor. For this purpose, the heating is interrupted periodically for brief instants during which the base-emitter voltage of the heating transistor, through which a constant current flows, is measured. Its value is stored in a sample & hold circuit and used to control the collector current of the power transistor during the next heating phase.

HEATING AND MEASURING

The circuit of the practical application of this idea is shown in **Figure** 1. Transistor T_1 is the heating transistor, which obtains its base current during the heating phase via CMOS switch IC_{2d} and resistor R_3. The heating current flows from the +ve supply line via T_1 and D_1 to earth.

To measure the base-emitter voltage, IC_{2d} is closed and IC_{2a} opened, whereupon the base of T_1 is at earth potential. Diode D_1 is reverse-biased and a constant base current for T_1 is drawn via R_6. The measured (negative) base-emitter voltage is applied to control amplifier IC_1 where it is compared with a reference potential set with P_1. The resulting voltage is stored in C_1 and used to drive T_1 during the next heating phase.

Circuit IC_3 is arranged as an astable (multivibrator) which provides the requisite pulses for the sample & hold circuit. The width of these pulses is about 1 ms (i.e., 100 Hz), during 800 μs of which T_1 is on (heating) and during the remaining 200 μs the base-emitter voltages is measured.

The output of IC_3 drives IC_{2d} directly. The pulse train is inverted by IC_{2b}, so that IC_{2a} and IC_{2c} are closed when IC_{2d} is open and vice versa.

The heating transistor is a darlington type. Any power darlington whose base-emitter resistances are ≤ 5 kΩ (R_{BE1}) and about 80 Ω (R_{BF2}) respectively may be used. On the one hand, this enables

a small base current to be used, which results in only a tiny dissipation in the CMOS switches, and yet produces, and controls, a large heating current. On the other hand, the two base-emitter voltages are in series and their sum total is perfectly usable as a measurand.

The power supply is traditional. So as to keep the dimensions of the printed-circuit board small, a 3.3 V transformer is used, which, however, can supply the requisite current for the circuit. At a heating temperature of about 40 °C, a current of about 35 mA is drawn from the positive supply line; when the heating temperature rises to 55 °C, the current becomes about 55 mA. The current drain from the negative supply line is independent of the temperature and is about 20 mA. There is a point to be borne in mind, though. For a short period (about 30 s) following power-on, the heating transistor is cold and draws as much current as the transformer can provide. It is, therefore, essential that the transformer is a short-circuit-proof type.

CONSTRUCTION

The thermostat is best built on the printed-circuit board shown in **Figure 2**. Note that the component layout is not in full accord with the introductory photograph, since during the final test stages it was found necessary to turn a few components about.

Most components, but not the power transistor, should be fitted in the usual order. Preset P_1 should be a type with a low long-term temperature coefficient, since it determines the stability of the temperature setting. Ideally, the preset should have a ceramic base plate.

Figure 1. Darlington transistor T_1 functions as a heating element for 80 per cent of the time and as a temperature sensor the remainder of the time.

Fit four soldering pins to the board to receive the oven—see Figure 2. Also fit three soldering pins to which T_1 will later be soldered. Note the tracks leading to the transistors, which are as thin as feasible to prevent any heat 'leaking' to the remainder of the board.

The oven is made from a 30 mm wide strip of tin plate by forming it into a box with a base surface area of 40–45 mm². This box is soldered to the four pins mentioned earlier. Press a

piece of 5 mm thick expanded polystyrene (area same as base of box) into the box so that the soldering pins for T_1 protrude through it. Then solder the base and emitter, but not the collector, of T_1 to the appropriate pins. Make sure that the cooling vane of the transistor is at the top. Be careful not to touch the polystyrene with the soldering iron.

CALIBRATION

Adjust P_1 for maximum resistance (normally fully clockwise). Connect a

Temperature dependence of quartz crystals

Quartz is a crystalline form of silicon dioxide (SiO_2). Most quartz is grown in large bars by dissolving SiO_2 in an alkaline solution at high temperature and pressure. The growing process takes about ten weeks.

The bars of crystal are cut into wafers. The angle at which these wafers are cut is crucial in determining the frequency and temperature stability of the final crystal. The most common cut is the AT-cut where the angle is about 35°, allowing a frequency range of 1 MHz to 300 MHz. Crystals can be made to oscillate at their fundamental frequency, or their third, fifth, or even higher, overtone (harmonic).

Frequency stability is normally specified as a frequency tolerance over a defined operating temperature range with respect to the frequency at reference temperature.

With reference to the generalized $\Delta f/f$ vs temperature (parabolic) curves shown, it should be noted that crystals with a small angle of cut show relatively small frequency deviations at the central temperature, but that the deviation is large at very low or very high temperatures.

Crystals with a large angle of cut behave in exactly the opposite way. For these, the deviation is relatively large at the central temperature, but very acceptable over the entire temperature range.

Which angle of cut is specified when maximum precision of frequency is required depends, therefore, on the application. For a laboratory equipment which is constantly in an ambient tempera-

ture of 20–30 °C, a small angle of cut is, of course, correct, whereas in an oscillator that operates over a wide temperature range, a large angle of cut should be specified. Best of all is, of course, to house the crystal in an oven at (near-) constant temperature.

As far as ageing characteristics are concerned, different rules apply. The frequency of the crystal should be as low as possible, that is, it should operate at its fundamental frequency. Moreover, it should be housed in a glass envelope instead of a metal one.

It is always wise in cases of doubt to consult the relevant data book, which are normally available free of charge from manufacturers.

Figure 2. Populating the board is straightforward, but constructing and fitting the oven may give some difficulties.

Parts list

Resistors:
R_1 = 4.7 kΩ
R_2 = 470 Ω
R_3 = 15 kΩ
R_4 = 100 kΩ
R_5 = 10 kΩ
R_6 = 1 kΩ
R_7 = 82 kΩ
R_8 = 27 kΩ
P_1 = 470 Ω preset

Capacitors:
C_1, C_3-C_5 = 10 nF
C_2 = 47 nF
C_6, C_7 = 100 µF, 25 V, radial
C_8, C_9 = 10 µF, 63 V, radial

Semiconductors:
D_1–D_5 = 1N4001
T_1 = TIP142 (10 kΩ/150 Ω)

Integrated circuits:
IC_1 = TL081
IC_2 = 4066
IC_3 = 555
IC_4 = 7808
IC_5 = 7908

Miscellaneous:
K_1 = 2-way terminal block for board mounting, pitch 7.5 mm
Tr_1 = mains transformer, 2x9 V, 3.3 VA (for instance, Velleman 2090038M from Maplin)

multimeter, set to its 200 mA d.c. range, between the +8 V line and the collector of T_1. Switch on the mains. The multimeter should show zero. Adjust it carefully until the meter reads 30 mA. This level will drop quickly when the transistor warms up. After about a minute, readjust P_1 to obtain a meter reading of 30 mA again. The preset may have to be readjusted again in the course of the next five minutes or so. At the end of this period, the operating temperature should have been reached.

During the calibration, it is important to monitor the temperature of the cooling vane of T_1. This is best done with a contact thermometer, but if this is not available, use an ordinary clinical thermometer. When the collector current has stabilized at 30 mA, the temperature of the vane should be 40–50 °C.

If all this is correct, solder the collector of T_1 to the appropriate soldering pin. Apply some heat conducting paste to the vane and fix the crystal onto the vane, keeping it in place with a brass clip or, if need be, with a couple of turns of nylon thread. The two devices normally need not be isolated, since the vane is connected to the collector.

FINALLY

Carefully solder two lengths of thin flexible, insulated circuit wire to the crystal terminals. Avoid overheating. Bring the two wires out of the box and fill this with further pieces or, preferably, pellets of expanded polystyrene.

Fit a lid on to the box and solder this into place at two opposite points. At all times, be careful not to touch the polystyrene with the soldering iron.

Cut the leads from the crystal as short as possible and wire them into the oscillator circuit.

All earth connections should be made to a single tag bolted to the enclosure. This tag should be linked with flexible circuit wire to the earth of the main equipment.

When the unit is connected to the main equipment, it will almost certainly be necessary to correct the calibration of the crystal oscillator slightly.

In normal operation, the oven will take about 10–15 minutes to warm up and reach a stable operating temperature.

[960071]

Figure 3. A cross section of the oven shows how the crystal/transistor combination is enveloped in expanded polystyrene.

1: board
2: tin-plate frame
3: lid
4: upper polystyrene plate
5: lower polystyrene plate
6: polystyrene strut
7: heating transistor
8: crystal
9: soldering pin

960071 - 12

video test chart generator

part 2: VGA mode, S-VHS and VGA

The main subject of last month's instalment was the structure of the PAL signal supplied by the test chart generator. In this second and final instalment we tackle the VGA mode and a number of non-theoretical matters including construction and practical use.

Design by W. Foede

As explained in Part 1 with the description of EPROM codes, the data for each pixel (R/G/B) consists of bit triplets D2/D1/D0 and D6/D5/D4. Bit D3 is the disable bit for all colours, allowing pixel bits to be used (as byte codes) for control purposes. With one exception, D3 is available in all byte codes. Only XINS (80_H) is not allowed to disable the colours, because R/G/B has to be inserted at WSS in line 23. The hexdump of a vertical sync pulse (**Figure 1**) shows the arrangement of the individual byte codes. FH2 (half horizontal frequency) is always switched on the falling edge of SHV (combined horizontal/vertical sync), in other words, also on each equalizing pulse and raster pulse, but not when D0 is set (detail 1). In the VGA modes, SHV may only contain steady line sync codes, and no vertical pulses with equalization pulses. In VGA modes, D4 (detail 2) ensures that SHV is omitted. In TV mode, D5 has the same function. D3, without D4 or D5, causes SHV to appear in TV as well as in VGA mode (detail 3). Basically the same applies to SV (vertical sync). D6/D3 set (detail 4) means SV in both modes. D1 also set means SV omitted with VGA. The same for D2 and TV mode. The bits allow you to adapt the syn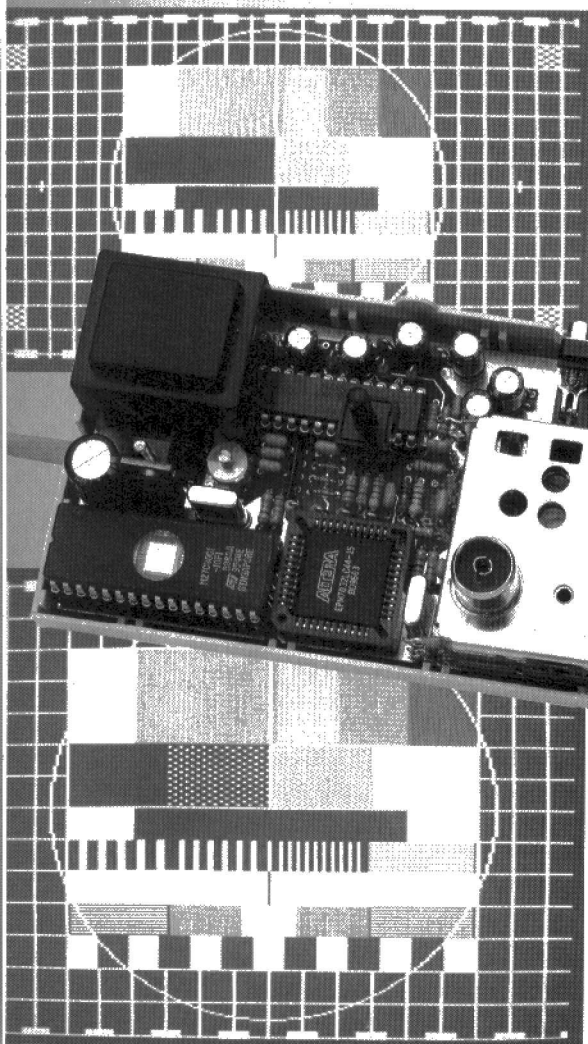c pulses to the relevant mode in any way you like. RESET should be added: D3/D7 works only with TV mode, and with D0 also set, with both modes.

As already mentioned, the circuit uses the same EPROM data for the VGA test charts and the TV test charts. The essential difference lies in the doubled clock frequency at which the EPROM is read. None of the other sub-circuits has to be switched separately, however, because the 8.86-MHz clock source (from which all frequencies are derived, with the exception of the WSS PALplus signal), is doubled to 17.7 MHz with the aid of an XOR gate inside the EPLD. The doubled addressing rate with VGA test charts causes a horizontal (line) frequency of $15,625 \times 2 = 31,250$ Hz, and a vertical frequency (FV) of $50 \times 2 = 100$ Hz. Al-

though the line frequency is fine, the raster frequency is a little too high for most monitors. That can be changed, however, by a larger number of lines per raster. Each line requires a storage capacity of 284 pixels $\times$ 4 bits = 1,136 bit (142 bytes); so, 354,432 bits for 312 lines. The RESET address for TV non-interlaced mode is then 354,432/8 = 44,304 or $AD10_H$. The available memory for a 16-bit address range is, however, 524,288 bits (512 k), allowing a maximum of $524,288/1,136 = 461$ full lines to be encoded. When the frame sync pulse is set to the start of the memory, RESET to address $AD10_H$ only for TV (88_H) and VGA RESET (89H) to 461 lines $\times$ 142 bytes = 65,462 ($FFB6_H$), then the VGA picture has 461 lines at FH = 31,250 Hz. That results in a raster frequency of 67.79 Hz, which should be okay for any modern VGA monitor. Provided the picture content is cleverly arranged, for example, colour bars without a circle as in test chart 2 (see table), then the transition from 312 to 461 lines is hardly visible. In VGA mode, TV test charts containing a circle are, of course, reduced in height about 1.5 times, and compressed. TV test charts 5 and 6 have 625 lines per frame, or 312.5 lines per raster, and are, therefore, interlaced. The TV RESET at 625 lines $\times$ 142 Bytes = $15AA_H$ is also applied as VGA-RESET (89_H), the total memory requirement (17 bit) being 1,048,576 bits. With two vertical sync pulses as with TV, we get FH = 31,250 Hz and FV = 100 Hz, 625 lines interlaced (VGA test chart 5). If the raster sync pulse for the second raster is suppressed, FH is not changed, although FV is halved to 50 Hz, 625 lines non interlaced (VGA test chart 6). That allows the vertical synchronisation of a multi-sync monitor to be checked from 50 Hz to 100 Hz. By adapting the number of picture lines, any raster frequency may be programmed.

The line frequency, too, is only limited by the smallest pixel duration of 112 ns. The desired line time is $n \times$ 112 ns, where n should be an even number, taking into account the byte code for RESET (89_H). If the number of pixels per line is reduced, the pixels become wider, as do any vertical lines, of course. When the generator is only

HEX EPROM-CODE 2

451ns/Byte (TV)
225ns/Byte (VGA)

```
00 00 00 00 00 00 59 58-58 58 58 58 58 58 58 58   ......YXXXXXXXXX
58 58 58 58 58 58 58 58-58 58 58 58 58 58 58 58   XXXXXXXXXXXXXXXX
58 58 58 58 58 58 58 58-58 58 58 58 58 58 58 58   XXXXXXXXXXXXXXXX
58 58 58 58 58 58 58 58-58 58 58 58 58 58 58 58   XXXXXXXXXXXXXXXX
58 58 58 78 78 78 78 78-78 78 78 78 78 48 48 48   XXXxxxxxxxxxxHHH
48 48 48 48 48 48 48 58-58 58 58 58 58 58 58 58   HHHHHHHXXXXXXXXX
58 58 58 58 58 58 58 58-58 58 58 58 58 58 58 58   XXXXXXXXXXXXXXXX
58 58 58 58 58 58 58 58-58 58 58 58 58 58 58 58   XXXXXXXXXXXXXXXX
58 58 58 58 58 58 58 58-58 58 78 78 78 78 78 78   XXXXXXXXXXxxxxxx
78 78 78 78 59 58 58 58-58 58 58 58 58 58 58 58   xxxxYXXXXXXXXXXX
```

960076 - 16a

HEX EPROM-CODE 960076 - 16b

Figure 1. The hex dump of a vertical sync pulse provides useful information on the structure of the individual byte codes.

used to test computer monitors, the frequency of crystal X2 may be increased to about 15 MHz, or even higher depending on what the EPROM will tolerate.

THE TEST CHARTS

The Altera EPLD type EPM7032 is supplied ready-programmed through our Readers Services under order code 966507-1, or through your kit supplier. The functions programmed into this IC are indicated in **Figure 2**. The 27C040 EPROM containing the data for the test charts listed in Table 1 is also supplied ready-programmed (order code 966507-2).

Test charts 1 through 4 occupy 512 kbit each, numbers 5 and 6, 1 Mbit each. The EPLD is automatically reset at power-on, so that test chart 1 appears in the first instance. The order and the possible memory space for each test chart is preprogrammed in the EPLD. A 3-bit counter, ACTR4, allows you to step through the test charts. Depending on the state of this address counter, A16 of the EPROM is driven either by A15 and ACTR3, or directly by ACTR4 to effect the test chart selection (see Figure 2).

Apart from the preprogrammed ICs for this project, a diskette is available which not only contains the standard test charts as shown in Table 1, but also data for 20 more test charts. The relevant files contain the data for a half-picture (raster). Using the instructions also provided on the disk you should be able to build your own test charts. The disk also contains a number of basic patterns such as sync pulses without picture content, a circle, a rhombus, and a grid, as well as precise indications about picture start, picture centre, picture end, WSS, and more. The test charts are programmed in Pascal because circles and characters are not easily produced manually from just pixels.

The following text discusses test charts numbers 1 (**Figure 3a**) and 5 (**Figure 3b**), which are universal charts, really. The foundation is a white grid on a black background, for checking the dynamic convergence and picture geometry. The vertical lines in the grid have the required width of 225 ns. The outer bounds of the grid are marked by white rhombuses. When the geometry is correctly adjusted, these 'diamonds' should just fall outside the visible area. Because sufficient black and

white areas are available in the rest of the screen, monochrome areas are not present in the colour bars. The vertical line at the transition from green to violet covers the unavoidable interference caused by the quarter-line offset which is inherent to PAL. The picture is programmed using only one bit per colour. Consequently a green bar is not possible, unless the colour contrast is reduced to nil. The replacement is the dot raster for focussing. The micro-rhombuses in the corners of test chart no. 5 serve the same purpose. To enable you to run a check on proper helper-line processing, the helper range in test charts 5 (**Figure 3b**) and 6 (**Figure 4b**) has a text insert which reads 'PALplus'. It appears as a white ident in the grey bar in test chart 5, and in the black bar in test chart 6. When not decoded, the text 'Palplus' appears in blue in the helper only. Test chart 6 also shows you which helper lines originate from the basic picture. The centre cross helps you to check static convergence. Next, the multi-burst has the smallest pulse width of 225 ns (TV) or 112 ns (VGA). The orange-coloured line raster has alternate red and yellow lines which serve to simulate at least the hue according to G−Y (approximately). Next comes a black pulse on white. The line rasters beside the red/yellow transition are line-wise blue/yellow, and operate just like the usual non-coloured areas. With the right phase positions of the generator and receiver colour subcarrier frequencies, these areas should be as

Figure 2. Block diagram of the programmed EPLD. Apart from two quartz oscillators, this IC contains mainly counters in combination with some control logic.

Figure 3. Test chart 1 (a) is the basic, universal, TV test chart. Test chart 5 (b) is the PALplus version.

colour-free as possible. The structure of the black/white rhombus and the entire picture in general is such that the circle covers as little white area as possible. Immediately after the vertical pulse of the first raster, all test charts have two test lines, a colour bar and a multiburst up to 4.43 MHz. By selecting TV raster triggering, and operating the oscilloscope in 2-channel mode, it is possible to analyse the colour signal and the video frequency response, independent of the actual test chart used, and without a second timebase. Because both lines are sure to occur in the blanked flyback period, they also allow the function of the cut-off to black during the flyback (picture blanking). VGA monitors are not particularly strong in this area! Fortunately, that is not a problem because the video signal is usually nought during this period.

CONSTRUCTION

A double-sided through-plated printed circuit board (**Figure 5**) was developed for this project to keep the construction as simple and compact as possible despite the relatively high frequencies used in the circuit. The printed circuit

board is available ready-made through our Readers Services. Mind you, the final design of the board has a few lay-out changes with respect to the first prototype shown in the photographs in last month's instalment.

The board should be populated with great precision because errors are not easy to trace later. With vertically mounted parts, short-circuits may be prevented by covering the long terminal with isolating pieces of wire sleeving. Take care to observe the polarity of diodes and electrolytic capacitors, and the orientation of the voltage regulator and all other ICs in the circuit. The ICs should be fitted as the last parts, and it is recommended to use IC sockets.

Two options are available for the power supply: either a small PCB mount transformer is used, or an external adaptor which is capable of supplying 9 Vdc at a current of about 150 mA. If the transformer is used, the PCB support pillar in the corner near terminal block K4 must be a plastic type. The alternative is not to secure this corner of the board at all. If the mains adaptor option is chosen, the following parts are not required: Tr1, K4, B1 and, of course, the mains on/off

switch. However, parts D5 and K3 are then required.

Whichever supply is used, the ground plane of the PCB and the screening at the inside of the enclosure should be connected by at least one mounting screw.

The test switch on the modulator

Table 1. Test Charts

No.	Pattern	Application
Non-interlaced (NI)		
1	Standard TV test chart	Universal
2	Colour bars	Faultfinding
3	Micro diamond	Focussing
4	Red	Colour processor
Interlaced/Line jump (I), PALplus		
5	as 1; 16:9 with PALplus ident	
6	as 2; 16:9 with PALplus ident	
VGA test charts:		
1	as TV 1; FH = 31.25kHz, FV = 100Hz NI	
2,3,4	as TV 2,3,4; FH = 31.25kHz, FV = 68Hz NI	
5	as TV 5; FH = 31.25kHz, FV = 50Hz NI	

Figure 4. Test chart 2 (a) shows colour bars and is suitable for faultfinding. The same for test chart 6 (b), which shows the colour bars in PALplus format with an ident.

Figure 5. Track layouts (75%) and component mounting plan of the printed circuit board. Note that the final layout differs slightly from that of the prototype shown in last month's instalment. Double-sided, through-plated board, available ready-made through the Readers Services.
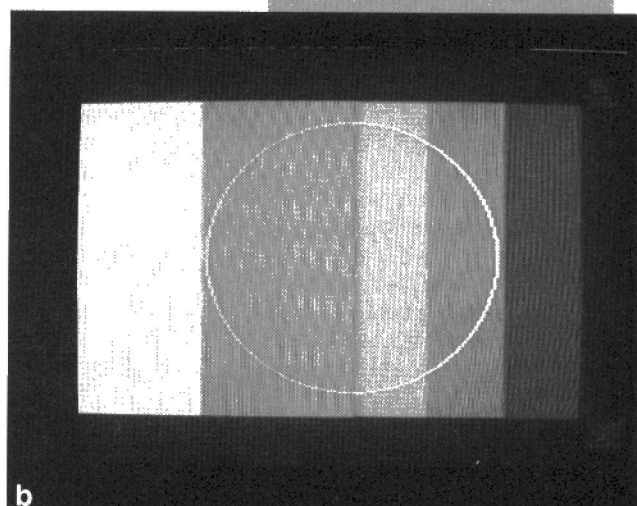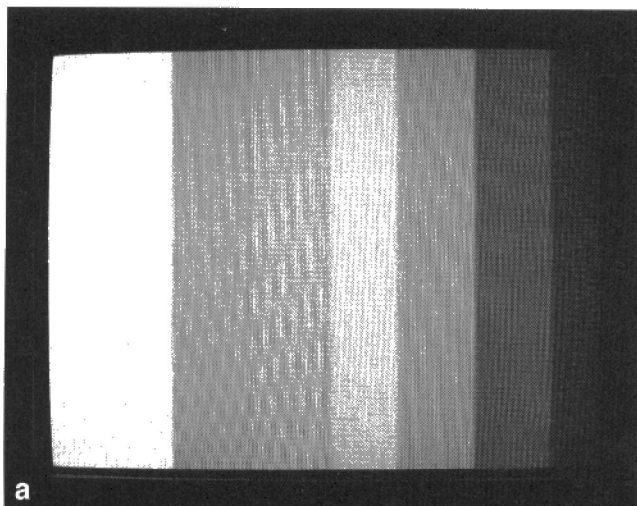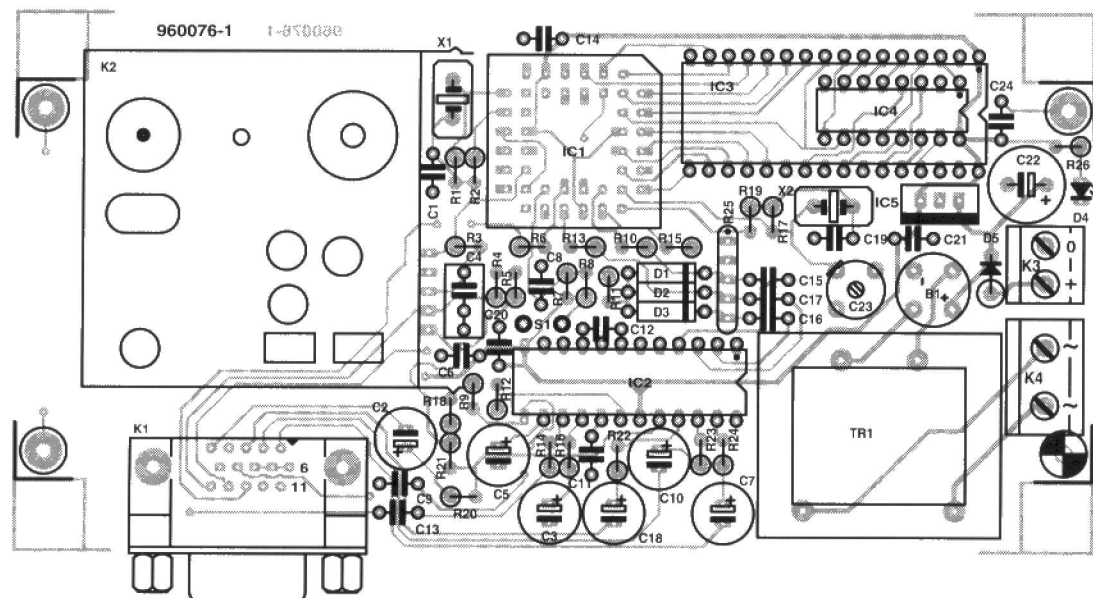
COMPONENTS LIST

Resistors:
R1 = 100kΩ
R2,R19,R26 = 1kΩ
R3,R8 = 10kΩ
R4,R7 = 2MΩ2
R5,R6,R14,R16,R20,R22,R23,
  R24 = 75Ω
R9 = 47kΩ
R10,R13,R15 = 390Ω
R11 = 100Ω
R12 = 15kΩ8 1%
R17 = 27kΩ
R18,R21 = 150Ω
R25 = 4 x 150Ω SIL array

Capacitors:
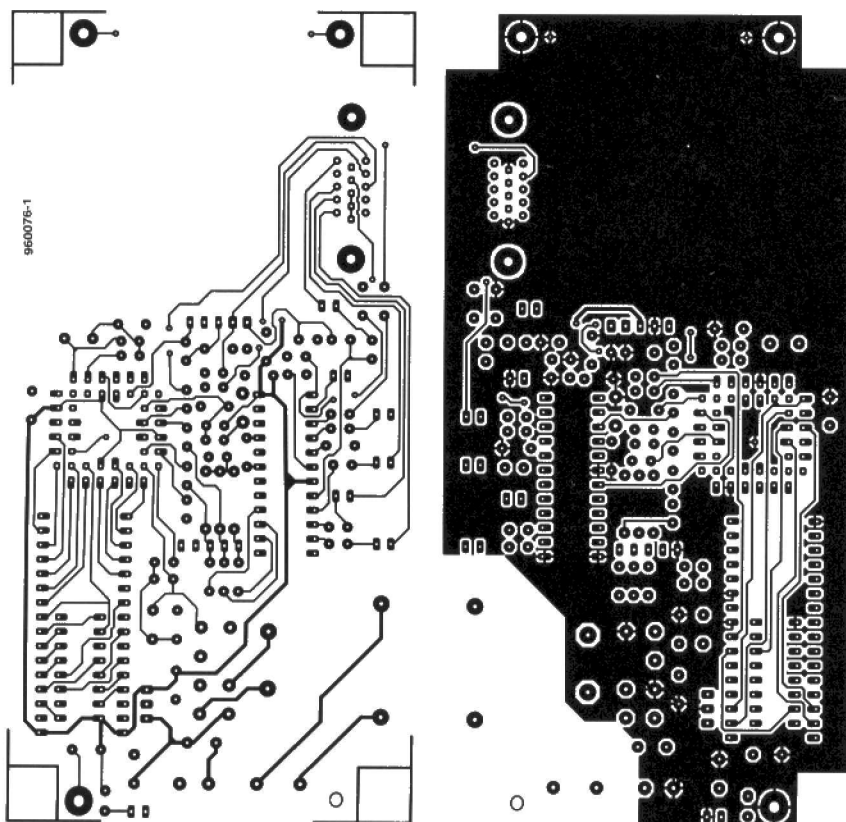C1,C19 = 100pF
C2,C3,C7,C10,C18 = 220µF 16V radial
C4 = 220nF
C5 = 100µF 16V radial
C6,C8,C9,C12-C17,C20,C21,C24,
  C25 = 100nF
C11 = 15pF
C22 = 1000µF 25V radial
C23 = 22pF trimmer
C25 = 47pF ceramic (see text)

Semiconductors:
D1,D2,D3 = 1N4148
D4 = LED
D5 = 1N4002 (see text)
B1 = B80C1500 (round)
IC1 = EPM7032LC44-15 (Altera) (order
  code 966507-1)
IC2 = CXA1645P (Sony)
IC3 = 27C040 100ns (order code
  966507-2)
IC4 = 74AC4040
IC5 = 7805

Miscellaneous:
K1 = 15-pin sub-D connector, VGA,
  high-density, angled pins, PCB mount
K2 = 2-pin PCB terminal block, pitch
  5mm
K4 = 2-pin PCB terminal block, pitch
  7.5mm
S1 = pushbutton, debounced (Conrad
  o/n 70 76 00-88)
X1 = 5 MHz quartz crystal
X2 = 8.867238MHz quartz crystal
Tr1 = Mains transformer, 6V, 2.4VA,
  Hahn.
UHF modulator (Conrad o/n 19 27 91-88
  or similar)
Screened case 150x80x45mm (Ham-
  mond 1591DGY or 1591DSBK)
Isolation set for T1, T2
Printed circuit board, programmed ICs
  (966507-1 and -2) and diskette
  966011-1: Set order code 960076-C.

unit is converted into a TV/VGA mode selector. Details of the conversion are shown in **Figure 6**. First, the non-used supply pin for the internal RF amplifier is 'freed' by cutting the track to pin 5 of the modulator at the underside of the module panel. As indicated, a wire connection is made from pin 5. Because of the wire jumper, the pole of the switch is permanently at ground level so that the test mode is no longer available. The third free switch contact now switches the VGA signal applied to pin 5 via the isolated wire.
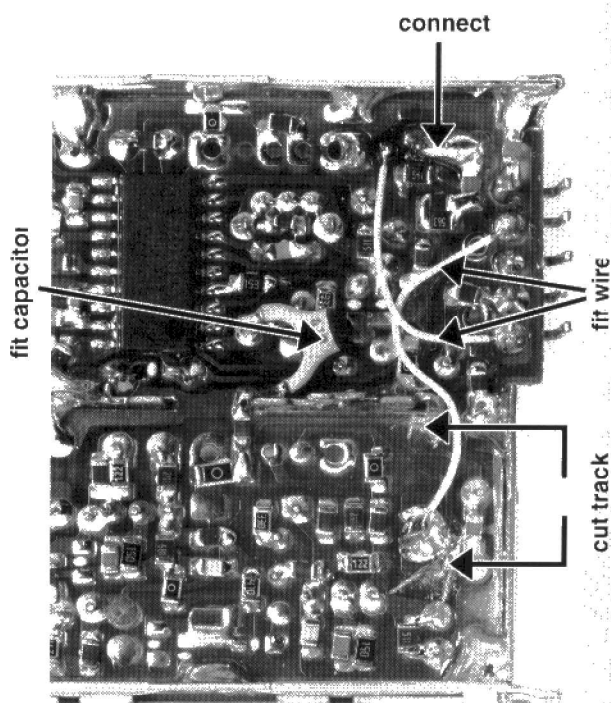
The non-used RF input socket on

the modulator is turned into an audio signal input. This requires 'freeing' the centre pin by a second track-cutting operation, and connecting it, via a length of isolated wire, to the audio input, pin 2. The external signal is injected via R4 (2.2 MΩ). The impedance of the modulator AF input is high enough to allow address signal A11 to produce an audible rectangle wave of about 550 Hz. When an external AF sound source is connected, the internal signal is practically quenched because of the low impedance. The AF input sensitivity is about 500 mV at 47 kΩ, allowing cassette decks, CD players and the like to be connected. The internal test tone may be muted by short-circuiting the AF input socket.

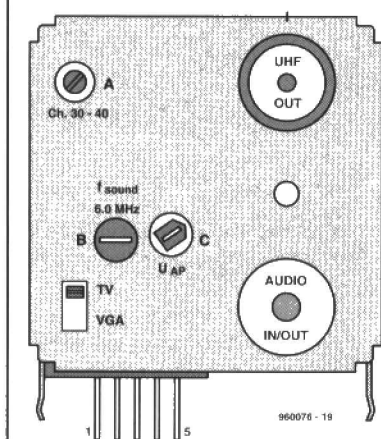Figure 6 also shows an additional ceramic capacitor of 47 pF which appears as

Figure 6. As described in the text, the modulator panel is slightly modified.

C25 in the parts list. This capacitor must be fitted with the shortest possible lead length at the indicated location. Without this decoupling device, the modulator picture suffers from sound carrier interference, which is particularly annoying in the decoded PALplus signal.

The modifications should be carried out with great precision, and checked with an ohmmeter. Mind you, that's less of an effort than having to remove the modulator from the finished board.

The five connecting pins of the modulator are bent at right angles. The modulator is then fitted flush on the board using four solder pins at the corners. In addition to the connecting pins, four mounting pins at the top corners are soldered to the board.

Figure 7. Connections and adjustment points of the UHF modulator.

CONNECTION AND ADJUSTMENT

Apart from the antenna output of the modulator, a 15-pin sub-D output socket is available to connect a VGA monitor. The CVBS and Y signal are output on non-used pins of the sub-D socket. The C signal is available on pin 11. With VGA, the colour subcarrier is switched off, leaving this pin available for ID0. Having a level of just 200 mV$_{pp}$/47 kΩ the AUDIO signal is hardly likely to cause interference at the ID1 pin (15). The remaining pin assignment corresponds to the VGA standard. **Table 2** shows an overview of the most commonly used video connectors and their pinning.

The test charts are selected by pressing S1. The only adjustment point on the board is trimmer C23. It is adjusted for a colour subcarrier frequency of 4.43361875 MHz in TV mode. If you have an accurate frequency meter, the signal may be measured at pin 6 of IC2. Without this instrument, you may also adjust the trimmer for the best possible colour reproduction in the test charts. The adjustment points of the UHF modulator are shown in **Figure 7**. The UHF channel (A) is adjusted such that the test chart does not become blurred (or the sound in-

terferes with the picture) when the TV is fine-tuned in the + direction. Because the modulator produces a double-sideband signal, it is possible to tune to the wrong sideband. The sound subcarrier is probably pre-adjusted to 5.5 MHz and may require tuning to 6.0 MHz as used in the UK. The test tone may sound a little harsh because it is derived from a rectangular signal – this is normal. The modulator bias (C) is also factory-adjusted. If you want to fine-tune this setting, note the colour yellow, the sound and the synchronisation. Yellow is a good indication of the video signal being clipped at the peak-white level.

(960076-2)

Table 2. Video connector pinout overview					
Video generator DC15HD (VGA)	SCART"E" S-VHS	SCART CVBS	SCART RGB	DIN AV*	HOSIDEN S-VHS
Pin 1 +R			15		
Pin 2 +G			11		
Pin 3 +B			7		
Pin 4 NC (ID2)					
Pin 5 +FBAS		20		2	
Pin 6 GND R	4, 17		4, 5		
Pin 7 GND G	14	4, 17	9, 13	3	1, 2
Pin 8 GND B			18		
Pin 9 +Y (NC)	20				3
Pin 10 GND					
Pin 11 C (ID0)	15				4
Pin 12 NC (ID1)					
Pin 13 -SHV(-SH)					
Pin 14 +SHV(-SV)			20		
Pin 15 AU (ID3)	2, 6	2, 6	2, 6	4, 5	
GND screening	21	21	21	3	5
RF Audio/Out					Audio/IN
* links pins 1 and 5 in plug					

sampling rate converter

for compatibility in digital audio

Although there are still dyed-in-the-wool sound technicians who swear by the good old analogue recording technology, most others, bitten by the digital audio recording bug, do not want to revert to analogue recording. They have experienced the pleasures of loss-free processing and copying of recordings at digital level. These pleasures turn to frustration, however, when they want to convert a DAT recording on to a CD. This cannot be done just like that because the two have different sampling frequencies: DAT 48 kHz, and CD 44.1 kHz. To overcome this difficulty, a converter as described in this article is required.

Design by T. Giesberts

It is a regrettable fact, with which we will have to learn to live, that different audio techniques use incongruous sampling frequencies (CDI – 18.9 kHz; 8 mm VCR – 31.5 kHz; NICAM – 32 kHz; CDI – 37.8 kHz; VCR – 44.056 kHz; CD – 44.1 kHz; DAT – 48 kHz; and others).

The growing popularity of digital audio is creating an increasing need of some means of coupling equipment using such different techniques – without loss of quality, of course. This can be done by altering the sampling rate in one of the two units to be coupled, while ensuring that the two sampled signals are adequately synchronized. Clearly, this requires a well-designed intelligent converter.

The design of the present converter is based on a dedicated IC: the Type TDA1373H from Philips. This circuit is very versatile and may be used for almost any imaginable conversion (but not quite – see later). Thus, it can be used for converting a DAT recording into a CD recording. Also, it enables CD data to be recorded on a DAT machine with a sampling rate of only 32 kHz, which, of course, results in a much longer playing time. Another possibility is converting the consumer standard S/PDIF* to the professional AES/EBU*

format. True, the converter has no AES/EBU connectors, but the conversion is possible.

Apart from as a converter, the circuit may be used as a copybit eliminator. In that case, the two sampling rates are made equal (as in the converter), but the category code, the copybit and the generation-status bit are set. The sampling rate used must correspond with the code set in most DAT machines to ensure that the signal is accepted.

Finally, the circuit may also serve as jitter killer since the first-in-first-out (FIFO) and gain stage in the TDA1373H suppresses any jitter.
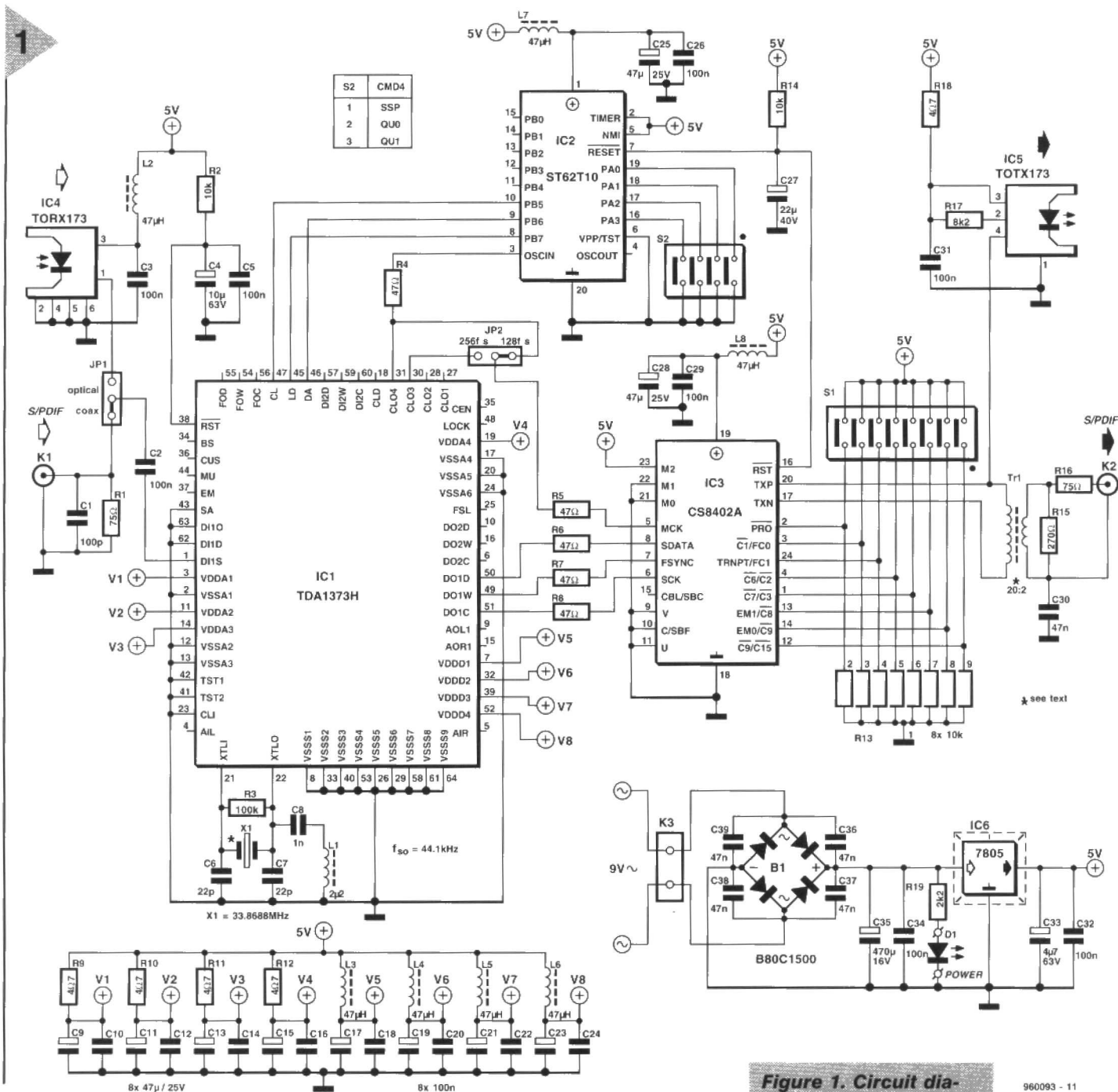
DESIGN

The circuit of the converter is shown in the diagram of **Figure 1**. Circuit IC_1 is the integrated digital converter, IC_2 is the controller, and IC_3 is the output interface.

The most important property of the TDA373H is the integrated Audio Digital Input Circuit (ADIC), which enables the chip to decode IEC958 signals (S/PDIF or AES/EBU). The circuit can work on a stand-alone basis or be controlled by a microprocessor. In the present circuit, it is controlled by IC_2, since this gives a wider choice of output formats. The circuit can process up to 20 bits and afterwards provides the con-

Figure 1. Circuit diagram of the sampling rate converter in which IC_1 is the actual converter, IC_2 is the controller, and IC_3 is the output interface.

960093 - 11

verted data in 16-, 18-, or 20-bit format.

The TDA373H is designed to provide up to four different applications, but since the present circuit is geared to being used as a sampling rate converter, the circuit is limited to this application.

The input of the converter may be optical (via IC_4) or coaxial (via K_1). The selection between these two is

by jumper JP_1, since it is assumed that the converter will be used invariably in a fixed setup in which there is seldom or never a need for changing from one to the other. The remaining two input pins of IC_1 are linked to earth.

Correct operation of IC_1 requires the setting of six command registers, which is effected by controller IC_2.

After a brief power-up reset (by R_{14}-C_{27}), IC_2 sends twelve 8-bit words (six addresses and data) to IC_1 via a serial connection.

The in-band noise shaper and the stop-band suppression of the ×64

Figure 2. IC_1 affords various functions. The relevant signal paths for the sampling rate conversion are indicated by bold lines.

oversampling filter are set by, respectively, sections 2, 3 and 1 of quadruple DIP switch S_2. The switches are debounced by a delay of 1–1½ seconds between their being operated and the relevant function being actuated. This delay is effected by the controller.

The sampling rate of the output signal, $f_{s(o)}$, of IC_1 is determined by the crystal between pins 21 and 22, according to equation

$$f_{x1} = 768 f_{s(o)}.$$

Thus, the crystal frequency should be 33.8688 MHz for a sampling rate of 44.1 kHz, and 24.576 MHz for a sampling rate of 32 kHz.

The sampling rate of the input, $f_{s(i)}$, must be not lower than $0.35 f_{s(o)}$, nor higher than $1.45 f_{s(o)}$. Thus, if the circuit is used as IEC598 decoder only, the input sampling rate should not exceed 45 kHz if the output sampling rate is 32 kHz. If conversion from 48 kHz to 32 kHz is required, consideration should be given to using two converters in cascade.

The converted data are available at serial digital audio output 1 and applied to output interface IC_3 via resistors R_6–R_8, which provide di/dt limiting.

Circuit IC_3 is a digital audio in-

terface transmitter Type CS8402. This IC can also process various formats, but in the present circuit the serial input (pins, 6, 7 and 8) is fixed for I^2S by the levels at inputs M0, M1 and M2. Virtually all functions of IC_3 may be obtained by appropriate setting of the various sections of DIP switch S_1.

The symmetrical output at TXP, TXN. is converted into a standard S/PDIF output (0.5 V_{pp} into 75 Ω). The electrical isolation provided by the transformer has the benefit of preventing earth loops.

An optical output is provided by optoisolator IC_5.

The power supply may be based on a standard 9 V mains transformer or mains adaptor rated at not less than 300 mA. The supply lines are stabilized by regulator IC_6 and lavishly decoupled as shown in the diagram.

THE TDA1373H

The TDA1373H, called general digital input, is a circuit that provides four different modes of operation. However, the present application is that of sampling rate converter, SRC, and, therefore, only the parts relevant to this will be discussed in this section.

In the block diagram in **Figure 2** the relevant signal paths are shown in bold lines.

The input signal is applied to the data slicer via pin DI1S. The slicer can handle signals at levels from 200 mV_{pp} to 5 V_{pp}.

The output of the slicer is applied to the audio digital input circuit, ADIC, which decodes the stereo audio samples, the word clock, the bit clock and various data (V, U, C and P) bits. The last function is not used here.

The ADIC locks to a 44.1 kHz signal in not more than 1 ms. Until it has locked, there is no word clock, and the audio bits are muted.

The output of the ADIC is applied to

Table 1. Two different response curves of the x64 oversampling filter can be selected with section 1 of DIP switch S_2.

| S2-1:				
bit SS	pass band		stop band	
0	$0–0.45351 f_{s(i)}$	±0.004 dB	$0.54648–1 f_{s(i)}$	−70 dB
1	$0–0.46875 f_{s(i)}$	±0.004 dB	$0.53125–1 f_{s(i)}$	−50 dB

Test results

The quality and properties of the sampling rate converter were tested in the digital domain at the various output formats. The (analogue) generator of an Audio Precision Analyser was used as the digital signal source, and this was coupled to a 20-bit analogue-to-digital converter (ADC). Of the four characteristics shown, I represents the output spectrum of the ADC. The other three characteristics may be compared with this.

Note how well the action of the in-band noise shaper is seen in Characteristic IV; a clear rise is discernible only in the (virtually inaudible) range above 18 kHz.

At the same time, and with the same setup, the signal-to-noise ratio for the various output formats was determined:

* 16 bit rounded off: −94.5 dB;
* 16 bit INS: −89.7 dB;
* 18 bit INS: −95.5 dB;
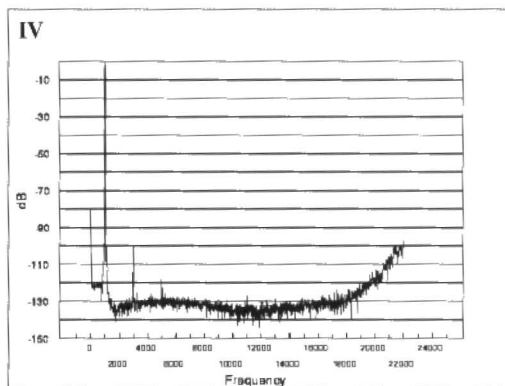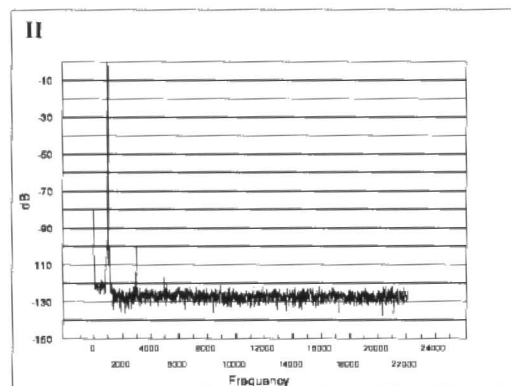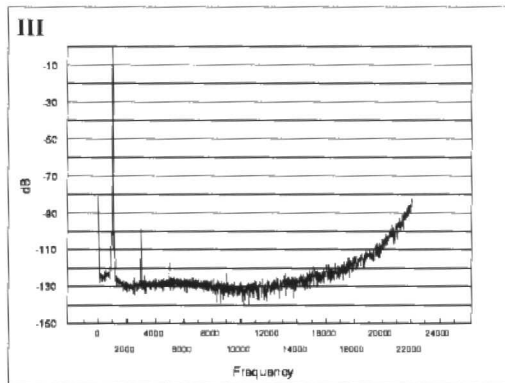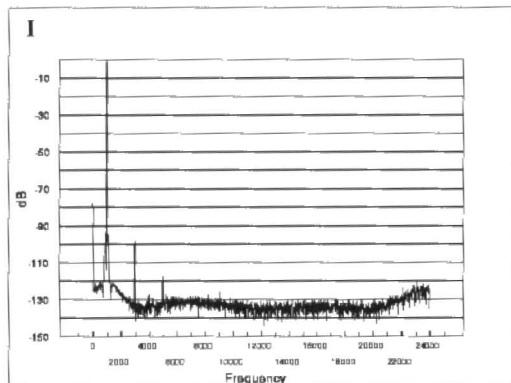
* II: 16 bit rounded off (section 2 of S_2 on; section 3 of S_2 on).
* III: 16 bit INS (section 2 of S_2 on; section 3 of S_2 off).
* IV: 18 bit INS (section 2 of S_2 off; section 3 of S_2 off).

No characteristic is shown for the 20-bit mode (section 2 of S_2 off; section 3 of S_2 on), since, at least up to 20 kHz, this is all but identical to the input signal of the converter (Characteristic I).

* 20 bit: −97 dB.

Note that the signal-to-distortion ratio of the ADC was 97.5 dB (measured without noise).

The signal-to-noise of the ADC plus sampling rate converter (without distortion) in the same test setup was about −107 dB (dynamic range of the ADC). The dynamic range, measured at a digital-to-analogue converter, DAC, was about 5 dB better with 16 bit INS than with 16 bit rounded off.

the first-in-first-out, FIFO, and gain stage. The FIFO section equalizes any speed variations of the incoming samples. Its size is eight samples and it ensures a tracking speed of 4 kHz ms⁻¹.

The gain section enables the signal to be amplified or attenuated. In the present application, the signal is attenuated by 0.068 dB to prevent clipping in the digital filters.

The samples are fed for interpolation to a ×64 oversampling filter. This filter consists of a ×4 section and a ×16 section. There is a choice of two filter characteristics: one with a

stop-band suppression of 70 dB and the other with a stop-band suppression of 50 dB but with steeper skirts. The second is intended especially for use with signals with a sampling rate of 32 kHz, and a pass-band of 0–15 kHz as, for instance, in digital satellite radio. The characteristics are selected by section 1 of DIP switch S_2 – see also **Table 1**.

The samples are applied from the filter to the variable hold stage in which the actual sampling rate conversion takes place. De-

Figure 3. IC₃ is a digital audio interface transmitter intended to encode and send audio data in accordance with the usual standards.

50 Hz to 0.5 Hz. The frequency difference is only 1 Hz for 512 input samples (10 ms for a sampling rate of 44.1 kHz).
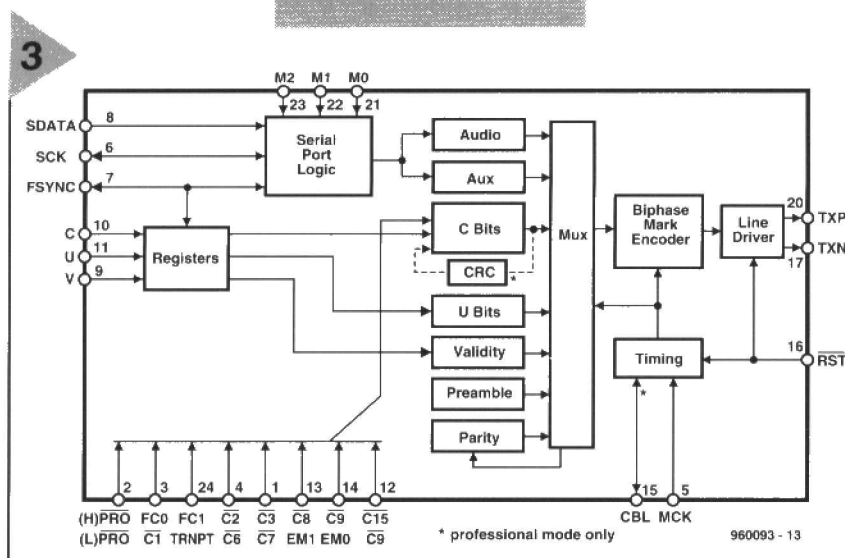
After the PLL has locked in, the audio signals are demuted and the conversion commences. To prevent any errors, the FIFO is monitored continuously in the variable-hold phase. As soon as the slightest tracking error is detected, the bandwidth of the loop filter is enlarged.

To convert the sampling rate to the requisite output value, the samples are passed through a ×128 down-sampling filter, which consists of a ×32 section and a ×4 section. The overall filter provides a stop-band suppression of 80 dB from 0.54648 of the output sampling rate.

Finally, the samples are applied to an in-band noise shaper, INS, which adapts the word-length of the samples to specific requirements. The standard length of 20 bits may be reduced to 16 bits or 18 bits by the relevant sections of DIP switch S_2. There are four possibilities as enumerated in **Table 2**, the first of

usual interface standards. The circuit provides the possibility of setting the most important channel status bits via seven inputs: pins 3, 24, 4, 1, 13, 14 and 12 in **Figure 3**. These inputs are controlled by octal DIP switch S_1 (see Figure 1). All seven inputs have a double function, which depends on the level at pin 2. This level is set with section 8 of S_1 and determines whether the IC works in the professional (AES/EBU) or in the consumer (S/PDIF) mode. The audio data are coded to the standard associated with the selected mode.

In the professional mode, a CRC code may be generated (channel status byte 23) as shown in dashed lines.

The serial input, pins 6, 7 and 8, can handle seven different formats and audio samples of 16–24 bits. In the present circuit, the format is fixed for I²S with M0, M1 and M2.

The serial inputs for channel status, C, user data, U, and validity, V, are not used and linked to earth. The V bit must be low to indicate that audio data are being processed which can be converted to analogue signals.

Pin 15, channel block start, CBL, is not used in the present application either. Normally, it is an output that may be used for writing C, U and V

bits. CBL is an input only when in the professional mode the transparent option is chosen (in which the C, U and V bits can be looped in via a receiver). In this way, synchronization of signals coming from separate equipment is possible. Normally, the master clock, MCK, is $128f_s$, where f_s is the signal frequency, but in the transparent mode, $MCK = 256f_s$. The multiplier is set with jumper JP_2.

PROFESSIONAL MODE
When pin 2, PRO, is low, that is, when section 8 of S_1 is closed, the digital audio interface transmitter, IC₃, is in the professional mode. In this mode, bits 1, 2, 3, 4, 6, 7 and 9 may be set after a 1 has been sent for channel status bit 0.

C0 indicates whether the channel status block applies to the professional (1) or the consumer (0) mode.

C1 determines whether the data are audio (0 – section 6 of S_1 closed) or

pending on the ratio of the input sampling rate and the output sampling rate, the sample is used once or twice, whence the name variable hold. When the ratio is 1:1, all samples are used twice, since the down sampling is ×128.

The variable hold function is controlled by a digital phase-locked loop, PLL, formed by the phase detector, loop filter, hold, and VCO (voltage-controlled oscillator) stages.

The loop filter ensures that the PLL locks rapidly. This is necessary because, after power-up, the bandwidth of the filter is reduced in two steps from 500 Hz to 50 Hz and then from

which is 20 bits.

The INS has a facility for adapting the digitization noise in a psycho-acoustical manner, whereby the noise to which human hearing is most sensitive is shifted upwards in frequency. This facility gives a subjective improvement of two bits with respect to the real quantization level.

Finally, the 20 bit length may be reduced to a 16-bit length by a simple rounding off action.

CODING & CONTROL
The digital audio interface transmitter, IC₃, is intended primarily for coding and sending audio data according to

Table 3b. Sampling rates in consumer mode.

S_1-8: PRO	S_1-6: FC1	S_1-7: FC0	
1	0	0	44.1 kHz
1	0	1	48 kHz
1	1	0	32 kHz
1	1	1	44.1 kHz, CD-mode

not audio (1 – section 6 of S_1 open).

C2, C3 and C4 are coded by EM0 (section 2 of S_1) and EM1 (section 3 of S_1) and determine the emphasis to be used: for instance, 110 is 50/15 μs.

C6 and C7 determine the sampling rate. The requisite setting of the rele-

Table 4. Setting the category code.

S_1-8: PRO	S_1-3: C8	S_1-2: C9	
1	0	0	general format
1	0	1	PCM-encoder/decoder
1	1	0	CD
1	1	1	DAT

vant sections of S_1 is given in **Table 3a**.

A 1 at C9 (section 2 of S_1 open) indicates a stereo signal; a 0 means that the mode is indeterminate.

In the transparent mode, none of the stated pins is used: the channel code is read at the c input only.

CONSUMER MODE

When pin 2, PRO, is high (section 8 of S_1 open), the digital audio interface transmitter is in the S/PDIF (consumer) mode. In this mode, bits 2, 3, 8, 9, 15, 24 and 25 may be set after a 0 has been sent for channel status bit 0.

C0 – 0 – indicates that the channel status block applies to the consumer mode.

FC0 and FC1 determine the sampling rate. The requisite setting of the relevant sections of S_1 is given in **Table 3b**.

C2 gives a choice between copy prohibit (0 – section 5 of S_1 closed) or copy permit (1 – section 5 of S_1 open).

C3 determines whether emphasis (50/15 μs) will be applied (1 – section 4
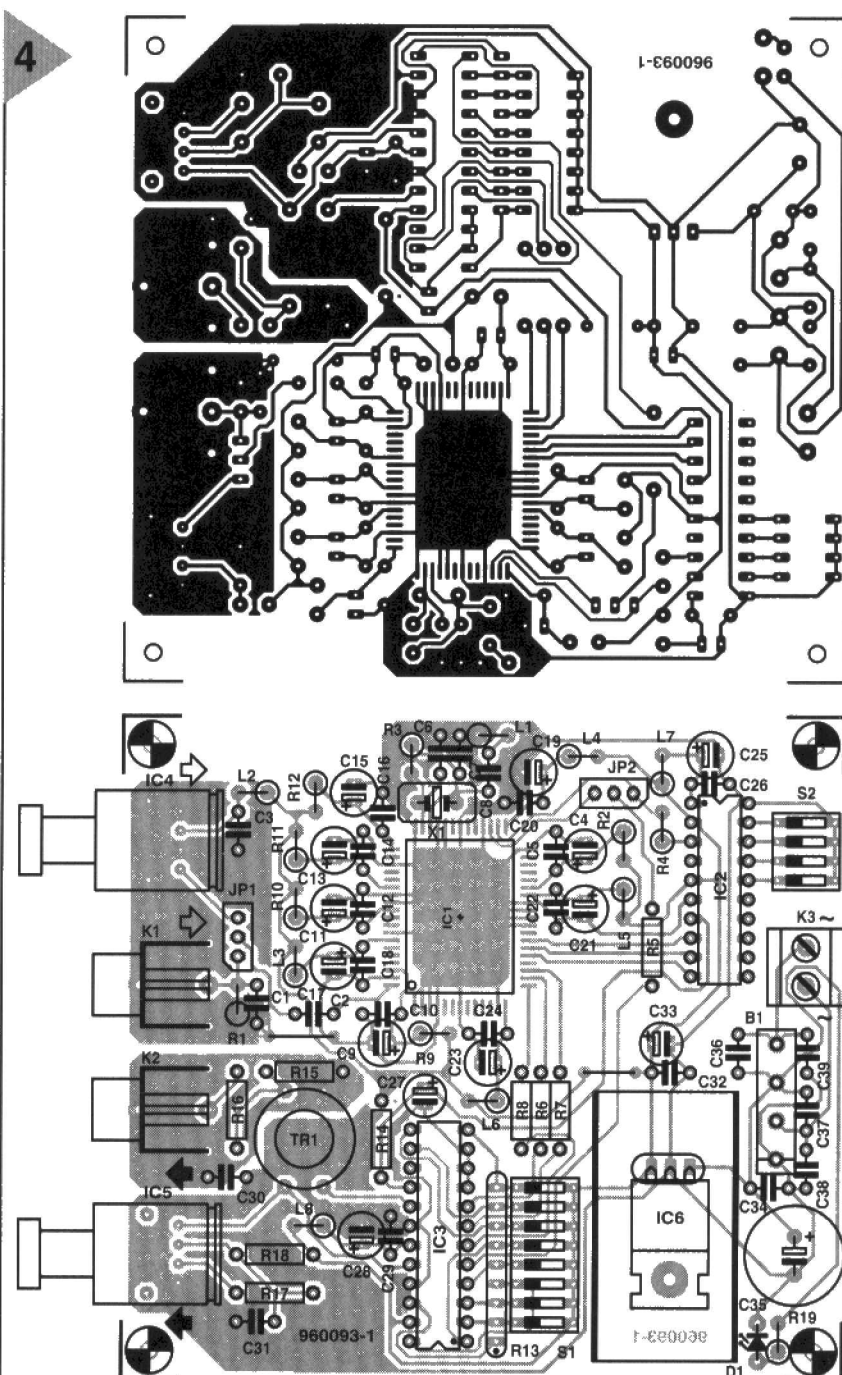
Figure 4. Printed-circuit board for the sampling rate converter. Note that IC_1, a surface-mount device, must be soldered at the track side.

of S_1 open) or not (0 – section 4 of S_1 closed).

C8 and C9 determine the category code: the requisite setting of the relevant sections of S_1 is shown in **Table 4**.

C15 is the generation status bit. Depending on the category code, the function of this bit, determined by the setting of section 1 of S_1, is inverted. When the category code is 001xxxx, 0111xxx or 100xxxx, a 0 indicates that the bit is an original and a 1 that it is a copy. With all other category codes, the reverse is true.

When the copy bit is 1, there is no copy protection, so that copying is possible. If the copy bit is 0, the generation status bit, in combination with the category code, determines whether copying may be carried out or not.

The outputs of IC_3 are RS422 compatible line drivers that go low when the IC is being reset.

Make sure that the channel status bits are active low and that a 0 is set by closing the relevant section of the DIP switch.

CONSTRUCTION

The converter is best built on the printed-circuit board shown in **Figure 4**. Although the board is compact, it affords ample space for all parts and components, including audio sockets K_1 and K_2 and optoisolators IC_4 and IC_5. It does not have space for the mains transformer, however. Note that controller IC_2 is available ready programmed through our Readers services (see towards the end of this issue).

Resistors:
R_1, R_{16} = 75 Ω
R_2, R_{14} = 10 kΩ
R_3 = 100 kΩ
R_4–R_8 = 47 Ω
R_9–R_{12}, R_{18} = 4.7 Ω
R_{13} = 8×10 kΩ array
R_{15} = 270 Ω
R_{17} = 8.2 kΩ
R_{19} = 2.2 kΩ

Capacitors:
C_1 = 100 pF
C_2, C_3, C_5, C_{10}, C_{12}, C_{14}, C_{16}, C_{18}, C_{20},
  C_{22}, C_{24}, C_{26}, C_{29}, C_{31}, C_{32}, C_{34} =
  100 nF ceramic
C_4 = 10 μF, 63 V, radial
C_6, C_7 = 22 pF

C_8 = 1 nF ceramic
C_9, C_{11}, C_{13}, C_{15}, C_{17}, C_{19}, C_{21}, C_{23},
  C_{25}, C_{28} = 47 μF, 25 V, radial
C_{27} = 22 μF, 40 V, radial
C_{30}, C_{36}–C_{39} = 47 nF, ceramic
C_{33} = 4.7 μF, 63 V, radial
C_{35} = 470 μF, 16 V, radial

Inductors:
L_1 = 2.2 μH
L_2–L_8 = 47 μH

Semiconductors:
D_1 = LED, low current

Integrated circuits:
IC_1 = TDA1373H (Philips)
IC_2 = ST6210 (see Readers services)
IC_3 = CS8402A (Crystal)
IC_4 = TORX173 (Toshiba)

IC_5 = TOTX173 (Toshiba)
IC_6 = 7805

Miscellaneous:
JP_1, JP_2 = 3-way pin header and jumper
K_1, K_2 = audio socket for board
  mounting
K_3 = terminal block, pitch 5 mm
S_1 = octal DIP switch
S_2 = quadruple DIP switch
Tr_1 = wound on G2/3FT12 core - see
  text
B_1 = rectifier Type B80C1500
X_1 = see text
Heat sink for IC_6: 29 k W^{-1}, for instance,
  Fischer ICK35/SA, available from Dau,
  telephone 01243 553 031)
PCB Order no. 960093 (see Readers ser-
  vices)
Mains transformer or mains adaptor,
  9 V, 300 mA
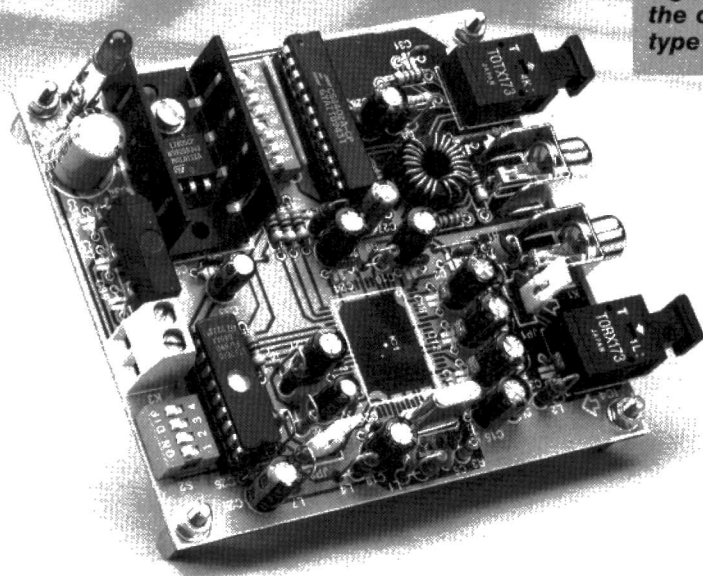
Figure 5. Top view of the completed proto-type converter board.

Figure 6. Mounting IC_1 may be a somewhat difficult task for beginners. Make sure that it is placed in the correct position.

The completion of the board should not present any undue difficulties – see **Figure 5** for a view of the top of a completed board. Note that IC_6 is mounted on an appropriate heat sink.

Less experienced constructors may find the mounting of IC_1 and the construction of output transformer Tr_1 not so straightforward.

Circuit IC_1 is a surface-mount device, SMD, which should be soldered at the track side (underside) of the board using an iron with a very fine tip – see **Figure 6**. Note the correct way of fitting: pin 1 is identified by a small disk on the case: this side must point towards the connectors on the board.

Transformer Tr_1 is a DIY device which is wound on a G2/3FT12 core. The primary winding consists of 20 turns, and the secondary of two turns, of enamelled copper wire with a diameter of 0.7 mm.(SWG22). Spread the primary evenly across the core, but leave some space at the centre for the two secondary turns that have to be wound subsequently.

When the board has been completed and checked thoroughly, a suitable mains transformer (9 V, 300 mA) or a 9 V mains adaptor may be connected to K_3. Indicator D_1 should then light.

Using a multimeter, check whether a stable potential of 5 V exists across C_{32} and C_{33}. If so, it is virtually certain that the converter will work satisfactorily. If it does not, recheck the board thoroughly. It is not possible to give suitable test points, since all that can really be checked are the supply lines.

(960093-I)

low-cost video fader

with just three parts

One of the first accessories almost any camcorder user will want to have is a simple fader which can help to soften the rather abrupt transitions between filmed shots. The circuit discussed here does just that without any power supply whatsoever. What's more, its component count being down to three, the fader is easily inserted into the video cable.

Design by K. Walraven
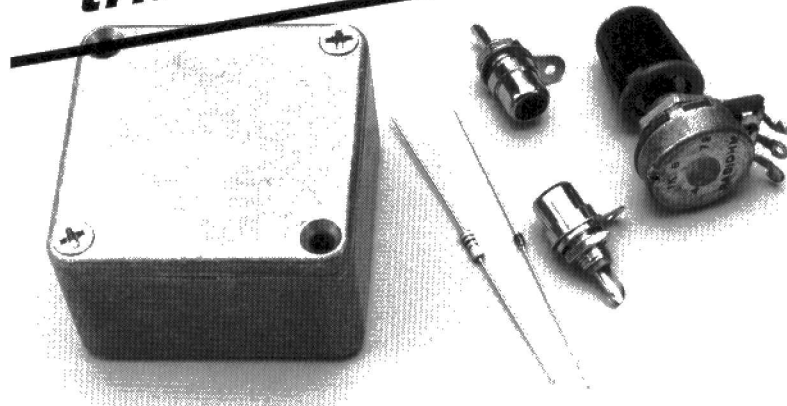
As long as audio signals are involved, a simple fader (level control) is no problem at all. A voltage divider in the form of an ordinary potentiometer will be just fine in many cases. Of course, the value of the potentiometer needs to be matched to the relevant input and output impedance, but that is rather easy. If quality is at stake, however, more components will be involved than just the one potentiometer. In professional mixing desks, the pot is usually surrounded by complex electronics, which serves to maintain steady terminating impedances at the input and output of each level control unit. The circuitry around the pot then also prevents the characteristic of the level control from being affected by the signal source. Be that as it may, a simple 'passive' volume control will be sufficient for many applications.

With a video signal, the situation is slightly more complex. Video signals are more complex than audio signals because they contain synchronisation pulses which can not be 'pinched off' just like that using an ordinary potentiometer.

VIDEO, BLANKING, SYNC.

The function of the basic components is discussed below, mind you, without going into details as regards the intricate structure of a video signal. **Figure 1** shows one line period.

The video signal is sometimes also referred to as 'composite video' or CVBS, which stands for colour, video, blanking, sync. For simplicity's sake, the colour component will not be discussed here. The drawing in Fig. 1 clearly shows that the larger part of the total swing of the signal (approx. 67%) is reserved for the V (video) component. This component determines the

1

white level

0%

10 - 12%

relative carrier level

black level

3 - 6%

22.5 - 27.5%

blanking level (ultra-black)

sync level

100%

64µs

1.55µs
4.7µs
5.8µs

A B C

relative amplitude

100 %

33
28

0

t(µs)

A = front porch
B = line sync pulse
C = rear porch

960048 - 11
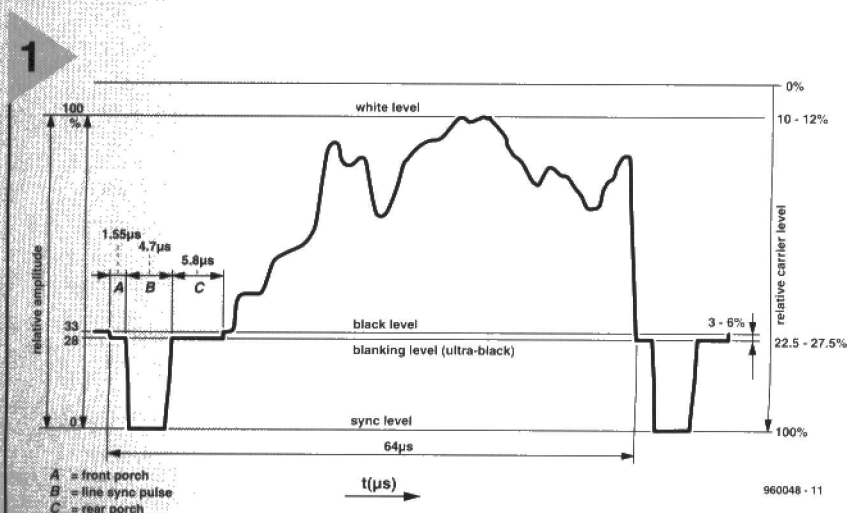
Figure 1. Composition of a video signal during one line period. For a video fader, it is essential that the sync pulses (B) arrive intact at the output.
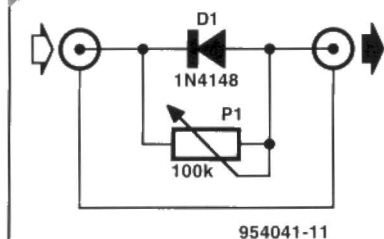
954041-11

Figure 2. The trick with the diode: when the video level is reduced with P1, diode D1 provides a safe by-pass for the sync pulses.

brightness of the individual picture elements should have relative to a pre-defined black level. The 4.7-μs long synchronisation pulses (B) are between 0 and 28% of the total swing. Each pulse arrives with a 'front porch' (A) and a 'rear porch' (C). During the complete period A+B+C, the electron beam inside the picture tube is quenched ('blanked') to enable the horizontal and vertical retrace (flyback) to become invisible during the line and raster synchronisation.

It will be clear that a CVBS signal can not be sent through a resistive attenuator just like that because the sync pulses are then also weakened. Assuming that a pot fader is used, a relatively short range will be available during which the video signal is actually reduced, but then the monitor or TV will suddenly lose sync, and the picture can not be viewed altogether. In other words, the single potentiometer, great as it may be for audio, is not suitable as a level control for composite video.

BY-ROAD:
FOR SYNCS ONLY

If you want to build a video fader which provides an acceptable fading range without sync loss, then care should be taken to attenuate the video component only, i.e., leave the sync pulses intact. If simplicity is not an issue, that may be achieved by using a so-called sync separator which extracts sync pulses from a CVBS signal, allowing these to be added again to the (attenuated) video component at the output of the fader. A perfect solution, true, but without doubt tied up to a rather complex circuit, which is not what we want here.

That brings us to the crucial question: is there a circuit which works, yet is wonderfully simple? Well, there is, if we apply a trick. The circuit of the 'Video Fader II' originally published in the December 1995 issue of *Elektor Electronics* is repeated in **Figure 2** for reference. The potentiometer is the least

conspicuous part, of course. In combination with the input impedance of the video input on the monitor, it forms an adjustable voltage divider for the video signal. The trick is the shunt diode which creates a kind of by-pass for the sync pulses. The input and output electrolytic capacitors in the camcorder and the video recorder cause the video signal level to be 'clamped' at a certain average value. Relative to that level, the sync signal forms a train of negative-going pulses which are allowed to travel (almost) freely through the diode. This little circuit appears to fit the bill perfectly: the pot allows you to turn the brightness down without the monitor losing sync suddenly.

PERFECTING
THE DESIGN

In practice, the circuit of Fig. 2 does have a few drawbacks, as some readers informed us. The operation of the fader is quite acceptable at high-impedance loads. However, when a terminating impedance of 75 Ω is used (which is customary with video equipment), the fade characteristic is far from ideal. Also, problems with sync degradation were sometimes reported. These problems are probably caused by the threshold voltage of the diode. All in all, sufficient reason to see if the circuit might be improved a little, provided, of course, it retains its charming simplicity.

Improving the 'flow' of the sync pulses was not difficult: all we had to do was replace the ubiquitous 1N4148 diode by a Schottky type BAT82. The lower threshold voltage of the Schottky diode ensures that the sync level remains intact at all times.

Improving the fade characteristic was far more difficult, as it turned out. It was clear that a parallel-connected potentiometer would be a better level control by definition, while also causing less of a mismatch. A practical problem arises, however: when the 'lower' terminal of the pot is simply connected to ground, and the wiper acts as the output, the inherent disadvantage is that the sync pulse is increasingly short-circuited to ground, together with the video components, as the brightness is reduced (fade-out). The diode, unfortunately, can not do anything about this situation.

One extra part, however, does the trick, see **Figure 3**. It may be too simple for words, but the crux of the revised video fader is the way R1 is con-

nected into the circuit. When the wiper of P1 is at the top position, R1 is just a harmless series resistor, and the video signal is passed with virtually no attenuation. When the wiper of P1 is turned to ground (fade-out), R1 prevents the signal from being short-circuited to ground behind the diode. Functionally, R1 changes from a series into a parallel resistor as the pot is turned. At the end of the travel, it is just a harmless terminating resistance.

It will be clear that no passive control will ever form a perfect match between a 75-Ω input and output. Fortunately, the mismatch of the circuit shown here is so small that annoying effects will not occur. On the contrary, this video fader gives a quite acceptable fading characteristic while still offering the advantage of a nearly unrivalled simplicity.

MATCHBOX SIZE

There is hardly a point in discussing the construction of the circuit. Obviously, there is no printed circuit board, while none of the regular construction problems will occur in practice. The only thing to keep in mind is that the wiring between the three components must be kept as short as possible.
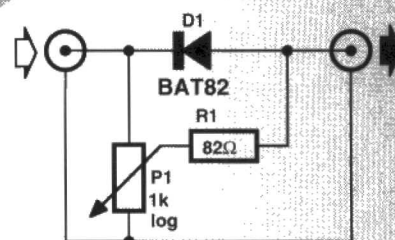
960048 - 12

Figure 3. The operation of the circuit in Fig. 2 may be perfected by adding a single resistor.

Diode D1 and resistor R1 are, therefore, soldered directly to the terminals of potentiometer P1. Add two pieces of coax cable, and Bob's your uncle.

An ultra-small enclosure, say, the size of a matchbox, and preferably made of metal, is sufficient to house the circuit. If small size is not your foremost concern, then a small diecast case like the Hammond type 1590LB is worth going for. Also consider using a slide potentiometer for P1, in which case a type 1590A enclosure (also from Hammond) will offer the necessary space.

(960048)

analogue-compass sensor Type 4070

The digital compass published in last month's issue of this magazine used a Pewatron Type 6945 magnetic sensor. This device was shown to enable the construction of an electronic compass with relatively few additional components. True, it has a resolution of only 45°, but this is perfectly acceptable for many applications.The analogue sensor, Type 4070, also from the Swiss firm Pewatron, enables a fully- fledged replacement (resolution 0.5°!) for a magnetic compass to be constructed. As already pointed out in last month's article,this requires fairly complex circuitry. Moreover, the data provided by the sensor cannot easily be evaluated without the use of a microcontroller.
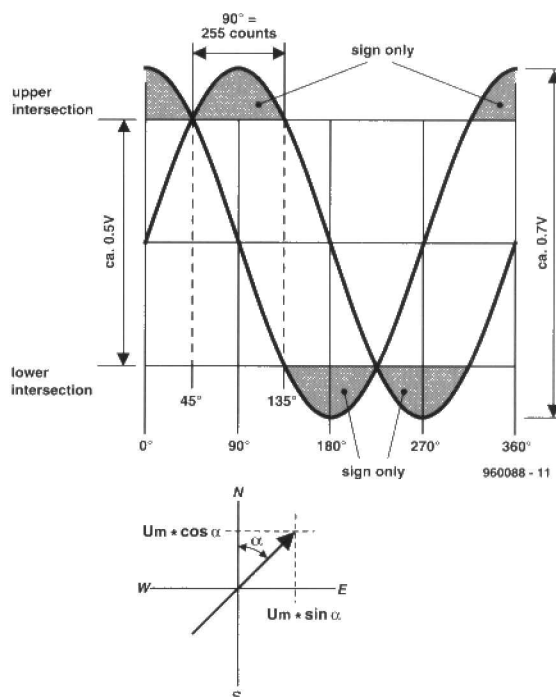
Figure 1. One output signal determines the quadrant, the other the exact direction.

Although the (analogue) Type 6070 sensor from the outside looks similar to the (digital) Type 6945, internally it is quite different.

The Type 6070 sensor provides two voltages that represent the orthogonal (right-angled) components of the direction vector within a quadrant—see **Figure 1**. In other words, the direction is resolved in a sine function and a cosine function. The functions,

$$U_{s1} = U_{max} \cdot \sin\alpha,$$
and
$$U_{s2} = U_{max} \cdot \cos\alpha,$$

are represented in the lower part of Figure 1. The sine and cosine curves have the same value, but in different directions, that is, 45°, or NE, and 225°, or SW, respectively.

These potentials determine the upper and lower intersections, U_U, and U_L respectively. The voltage at the centre between them, U_M, is taken as the zero point. The output signal swings between 2.1 V and 2.9 V approximately, so that the centre voltage is 2.5 V. The exact value is very accurate, but plays no further role, since it is excluded in the subsequent signal process.

The output voltage range is ±350 mV to ±375 mV, but between the intersections it is only ±250 mV.

To evaluate the two output potentials, the section of the curves between the two intersections is taken as linear. Only the voltage outside the range between the upper and lower intersections determines the four quadrants as follows:

sine curve above U_u :   45–135° (NE–SE)

cosine curve below U_l: 135–225° (SE–SW)

sine curve below U_l: 225–315° (SW–NW)

cosine curve above U_u: 315–45° (NW–NE)

The remainder of the curve lies in the relatively linear range with a voltage sweep of some 500 mV/90°, that is, about 5.5 mV per degree. If this range is evaluated with a resolution of 8 bits = 225 steps, each step is 2 mV or 0.35°. The inherent error owing to the non-linearity

of the curve is about ±5 per cent, which does not do the accuracy of the sensor justice.

Fortunately, the use of a microcontroller allows a much more precise evaluation. In this way, a correction table can be stored in an EPROM, or the measurement result can be made more accurate by an appropriate algorithm (angular function).

SOME PROPERTIES OF THE SENSOR

The Type 6070 sensor is 12.7 mm high, has a diameter of 12.7 mm, and weighs 2.3 g. It is suitable for operation over the temperature range of –40 °C to +85 °C. It has six terminals, of which four are used for connecting to the supply lines (see **Figure 2**). The sensor requires a simple but well-regulated power supply of +5 V. It is well worth bearing in mind

APPLICATION WITH CONTROLLER

Figure 3 shows a typical application of the sensor in combination with an adder. This amplifier not only raises the signal ×10, but also removes the centre voltage from the signal. To ensure optimal operation of the analogue-to-digital converter (ADC), variable amplification is indispensable. This is provided by a preset in the feedback loop.

A load current of up to 4 mA may be drawn from the outputs of the sensor, which means that a wide variety of operational amplifiers may be used.

Finally, the two processed analogue signals are digitized as shown in the block diagram of a complete compass in **Figure 4**. This may be ef-

view from above
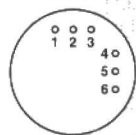
1: +5VDC/Vcc
2: Ground
3: Output curve 1

4: +5VDC/Vcc
5: Ground
6: Output curve 2

12.7mm
12.7mm
3mm
12.7mm
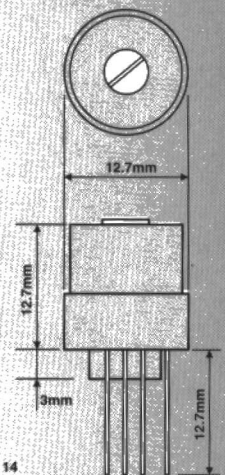
960088 - 14

Figure 2. Dimensions and pinout of the Type 6070 sensor.

display or liquid crystal display (LCD) to be driven.

TIPS ON USE
The sensor is highly sensitive to external magnetic parts. It is, therefore, advisable when building a compass to check that components used are not magnetized, since this will almost certainly cause the compass reading to have an error. Nevertheless, the effect of the earth's magnetic field is not limited in any sense. Also, the sensor is not damaged by other extraneous magnetic fields.

Note that the IC in the sensor can be damaged by sustained (>4 s) heat from a soldering iron, which should have a temperature not exceeding 360 °C. If in doubt about the temperature, it is advisable to use a heat deflector such as a pair of flat-nose pliers around the wire being soldered.

[960088]
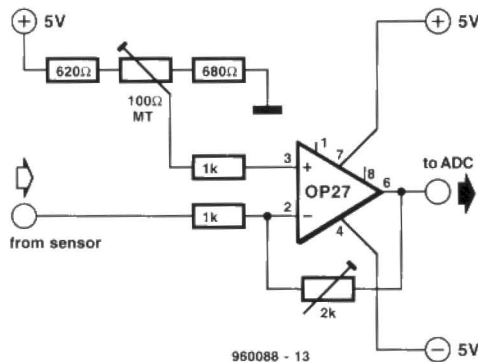
960088 - 13

Figure 3. A variable adder removes the centre voltage and matches the sensor to the analogue-to-digital converter.

that this expensive device (about £70 or $US 110) is easily damaged beyond repair by pulses and other interference on the supply lines. The regulation should, therefore, be as close to the sensor as possible and certainly provide good protection against voltage peaks and, in case of mobile use, polarity reversal. The sensor draws a current of 18–19 mA.

The sensor is a combination of a miniature motor with sapphire bearings, a Hall effect IC and a magnet. It is mechanically damped so that the output needs about 2.5 s to follow a change in direction of 90°. This is similar to the fluid damping in a magnetic compass and prevents the reading from overswing and fluttering around the real value.

The construction is such that when the sensor is mounted vertically it does not respond to the horizontal component of the earth's magnetic field. If it is not exactly vertical, inclination errors are likely to occur.

fected by an ADC and multiplexer or by two discrete 8-bit ADCs, such as the Type 0804. Another possibility is using a microcontroller with integral ADC, such as the 68HC11, the 80C535, one of the ST6xx series, or a Type 16C71 or 16C74 peripheral interface controller (PIC). When choosing a controller, make sure that it has an adequate number of port lines to enable an LED
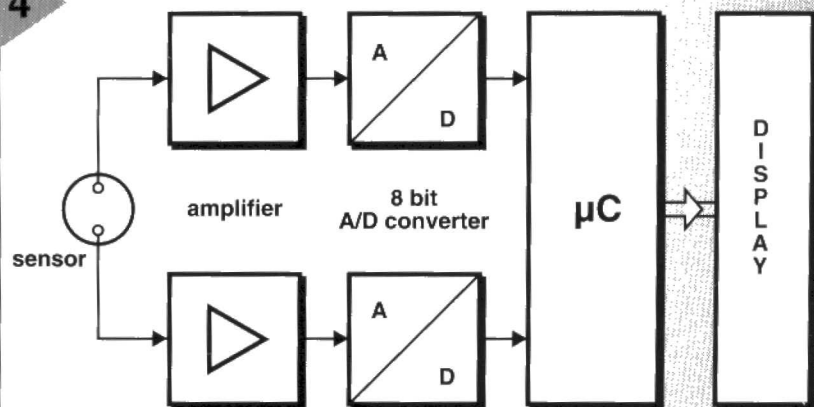
Figure 4. Block diagram of a complete compass using a microcontroller.

sensor   amplifier   8 bit A/D converter   µC   DISPLAY

960088 - 12

1995 content on CD-ROM

Elektor Electronics in digital form? Yes! From now on you will be able to inspect and study all articles that appear in the eleven annual issues on your computer screen. The 1995 content is now available on disk in four languages: Dutch, English, French and German.
These languages are used because they are the main languages in which the magazine is published (although there are also issues in Greek, Hebrew, Italian, Polish, Portuguese, Spanish and Swedish).

The first CD-ROM – the guinea pig – contained the 1994 annual content in Dutch, purely because the Netherlands is a fairly easy testing ground. The response was good enough to convince us that there should be a disk for subsequent years and then in the four main languages used in our company. Moreover, CD-ROM drives are now available for such low prices, that we feel that almost any reader of our magazines has access to one.

one of them, it appears on the screen in a separate window.

In the case of circuit diagrams and board layouts, the left-hand and right-hand mouse keys enable zooming in and out.

Board layouts are shown in 600 dpi to enable you to make good-quality copies for producing and etching the board yourself.

The text, or part of it, may be copied and modified without any problems, for instance, for reviewing purposes (do not forget to mention the source in that case).

There are many more facilities
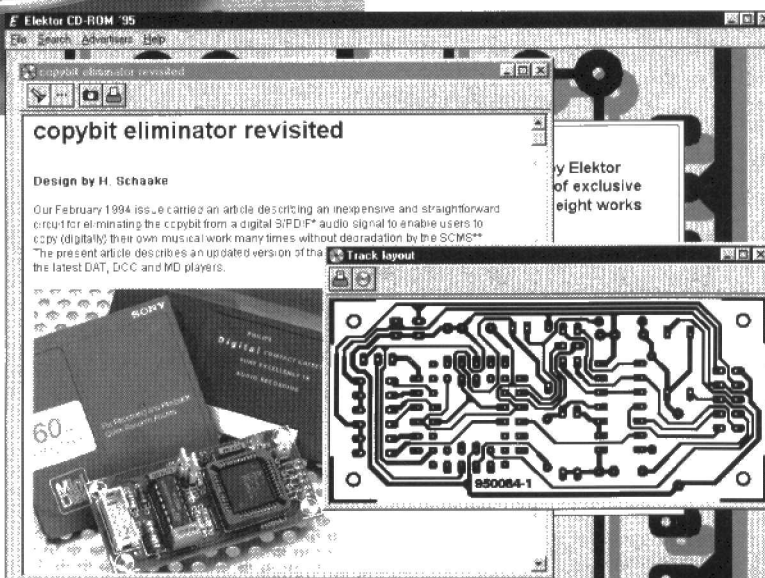
FACILITIES

Needed for using the disk is an IBM (compatible) PC with a 386 or higher, not less than 4 MB RAM, a VGA screen, and a CD-ROM drive. The program on the disk runs under Windows 3.1, 3.11 and 95.

The program is designed so that you need not install anything on your hard disk. After it has been started, a box appears in which one of the four languages can be selected. Once this has been done, the program remembers it and next time your start, it will automatically open in the selected language.

Next appears a complete overview of all articles published during 1995 (but not news, new products, new books and similar columns). You may also select an overview of a particular month, whereupon the cover of that month is shown.

After an article has been opened, first the text and all photographs (if any) are shown. All circuit diagrams, printed-circuit board layouts, other drawings and tables, which can be selected individually, are shown in the text in colour. When you can click on

built in, too many too mention in this short note. Suffice it to say that the design differs considerably from that used by many other magazines. These normally convert existing DTP (desktop publishing) files into so-called HTML or PDF files. These files do not have a sufficiently high resolution as far as circuit diagrams and board layouts are concerned (or they are so large that they make the computer very slow), and we feel that just these are of particular importance to our readers. Our disk has the great advantage that the text as a whole remains perfectly legible and that only those illustrations are shown that you select. Text and illustrations may be said to be independent of one another.

A final point: if you buy the CD-ROM, please let us know of any CONSTRUCTIVE criticism you may have; this will only make next year's disk better.

The recommended retail price of the CD-ROM is £ 41·00 or $US 65.00, but subscribers to the magazine qualify for a 10 per cent discount.

[960101]

electric-bulb tester
with wattage indication

With the electric-bulb tester you cannot only verify whether a bulb is still in working order, but, if so, also find its wattage. True, this power rating is normally stated on the bulb, but it happens frequently that, after a time, this is no longer legible. The tester indicates whether the bulb in question is rated at 15, 25, 40, 60, 75 or 100 watt. Now, isn't that handy?

Design by H. Schaefer

If all that needs to be ascertained of a bulb is whether it is still usable, a special tester is not really required. It is quite easy to substitute it for a known working bulb in a standard or desk light. However, a tester that works without the need of mains voltage is, of course, always safer.

A different situation arises when you often have to deal with suspect bulbs. Also, if a defect bulb is to be replaced by one from an assortment of spare bulbs whose wattage is undecipherable, a simple tester like the one described here becomes indispensable.

An ohmmeter is all that's required to check the continuity of the filament of the bulb. If the filament is broken, it has a very high resistance, but if it is all right, the resistance is low. Moreover, the value of the resistance is a (rough) measure of the wattage of the bulb, as is shown in the two right-hand columns of **Table 1**. These columns give the filament resistance (when the filament is cold) of the most common bulbs.

So, Table 1 and an ohmmeter (or multimeter) make it possible to find out the most important aspects of a bulb. This method is not very convenient, however, and this article, therefore, describes a rather more user-friendly way.

DISPLAY DRIVER

It is not necessary to measure and interpret resistance values. The cold resistance of most bulbs may be converted into a voltage with the aid of an auxiliary (test) current. This voltage may be used to actuate a circuit, which

is kept simple by the use of a display driver Type LM3915. This device makes displaying the voltage very simple indeed.

The driver, whose block diagram is shown in **Figure 1**, is specially designed to display analogue voltages on an LED scale. For this, the IC needs an internal voltage reference, a multi-section precision potential divider, and a number of comparators, the output of each of which can drive an LED.

The potential divider is arranged so that the LED display forms a logarithmic scale in steps of 3 dB. This means that each comparator threshold is higher by a factor 1.414 than its predecessor.

The measurand (that is, the quantity – here voltage – to be measured) is applied to pin 5. The input voltage range may conveniently be set by adapting the reference potential. The internal voltage reference provides a potential of 1.25 V across pins 7 and 8. It is thus a simple matter of setting a given voltage between pin 7 and earth with an external potential divider. Note, however, that this has its limits, since the resistance between pin 7 and earth determines the brightness of the LEDs. The current through the LEDs is about ten times as high as that through this resistance.

CURRENT SOURCE

All that is needed additionally to turn the display driver, IC_1, into a bulb tester is a constant-current source. When this sends a current through the bulb on test, a potential difference ensues across the filament. This voltage is
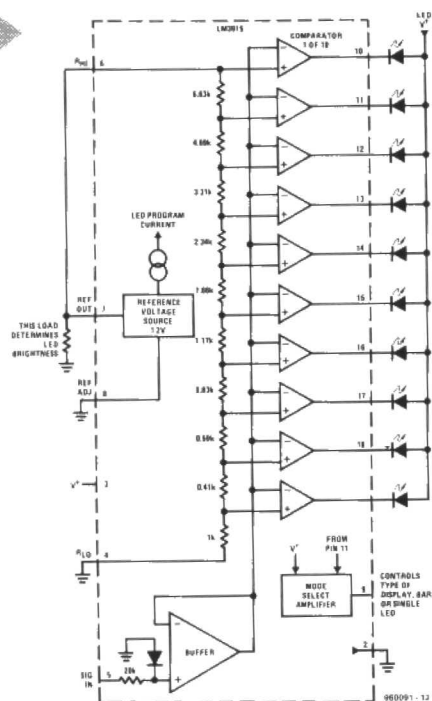
Figure 1. Block diagram of display driver Type LM3915.

applied to pin 5 of IC$_1$. Depending on the level of this voltage (which is directly proportional to the wattage of the bulb), one of the LEDs lights. Since the IC works very well with low voltages, the current from the source need not be large. A current of 5 mA was decided upon, which helps to extend the life of battery Bt$_1$. **Table 1** gives the correlation between the test current and the resulting voltages.

In the design of the current source, the internal voltage reference of IC$_1$ was used—see the circuit diagram in **Figure 2**. As already stated, the 1.25 V reference potential is available between pins 7 and 8. This means that the voltage drop, U_D, across R$_1$+R$_2$ is 2.2 V. This potential is the upper limit of the measuring range, since pin 7 is linked to the upper terminal of the internal potential divider, that is, pin 6. Therefore, D$_1$ will light only when the input voltage applied to pin 5 exceeds 2.2 V. All other threshold voltages are derived from this and are given in Table 1.

The voltage drop across R$_1$+R$_2$ is applied to the base of transistor T$_1$. This means that the voltage drop across R$_4$ is 2.2–0.6 = 1.6 V. With the specified value of R$_4$, this results in an emitter current of about 4.8 mA. Since the collector current is virtually identical to the emitter current, the current through P$_1$+R$_3$ is also 4.8 mA. This makes it possible for P$_1$ to adjust the base voltage of T$_2$ to a level that results in a potential difference of exactly 1.1 V across emitter resistor R$_5$. This means that a stable current of exactly

5 mA flows through R$_5$ *and* the filament of the bulb on test which is connected in series with the collector circuit of T$_2$.

The voltage drop across the filament resistance, R$_x$, is applied to pin 5 of IC$_1$: Table 1 shows which diode will light at what voltage.

Laboratory tests with a variety of electric bulbs showed that the voltages resulting from the 5 mA test current neatly fell between successive switching thresholds of IC$_1$. Only the test voltage for 25 W bulbs (0.750 V) may give difficulties since this is very close to the next highest threshold of 0.7980 V.

Depending on the tolerances of the components used and the accuracy with which P$_1$ is adjusted, it may be desirable to link D$_3$ to pin 14 instead of to pin 13. This can be done conveniently with jumper JP$_1$.

cases, it will be found best not to solder them directly to the board, but to mount them in the lid of the enclosure and link them to the board with insulated flexible circuit wire.

A photograph of the completed prototype board is shown in **Figure 4**.

Power for the tester is best supplied from a 9 V battery. Since the circuit draws a current of only 15 mA and only then when the test button, S$_1$, is pressed, the battery will have a long life.

Even including the battery, the volume of the tester is small, so that finding a suitable plastic enclosure should not prove difficult. It is, of course, important that the LEDs are clearly visible, that S$_1$ is easy to operate, and that robust, high-conductive (copper) strips are used for attaching the bulb on test. The distance between the strips may be slightly less than that between the contacts on the bayonet fitting of the bulb. If continental, screw-type bulbs are to be tested, the strips should be arranged with one horizontal and the other so that it connects readily with the screw thread of the bulb.

See also the wiring diagram in **Figure 5**.
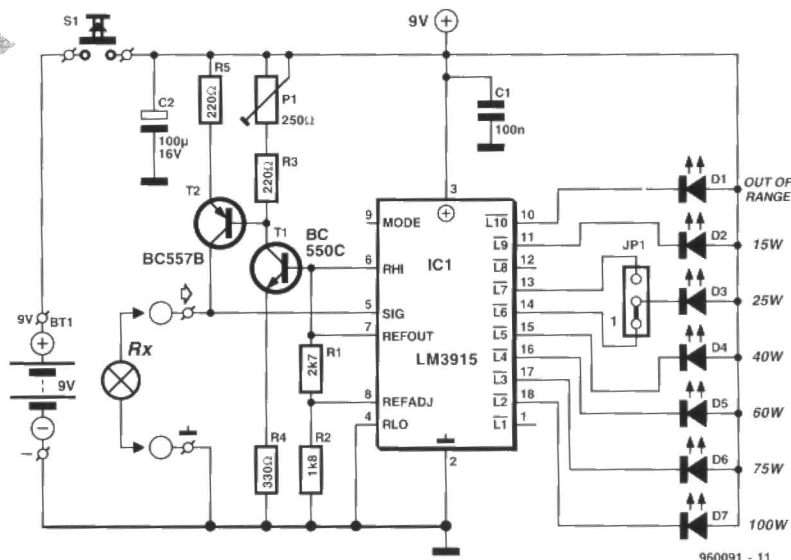
Figure 2. All that is required to turn an LM3915 into an electric-bulb tester is a constant current source.

CONSTRUCTION

The electric-bulb tester is best built on the printed-circuit board shown in **Figure 3**, which is available ready-made through our Readers services (towards the end of this issue).

It is advisable to use a suitable socket for IC$_1$.

Mind the polarity of the LEDs: almost invariably, the shorter terminal is the cathode. How these diodes are best mounted depends to a large extent on the enclosure used. In most

SETTING UP

After the board has been completed, check it thoroughly with reference to Figure 3 and the parts list. Make sure that the IC is slotted correctly into its socket. When everything appears to be in order, connect the battery and, using a multimeter set to the 5/10 V d.c. range, check the voltage between pins 2 and 7 of the IC, which should be about 2.2 V – do not forget to press S$_1$. Any variations of this voltage should be cor-
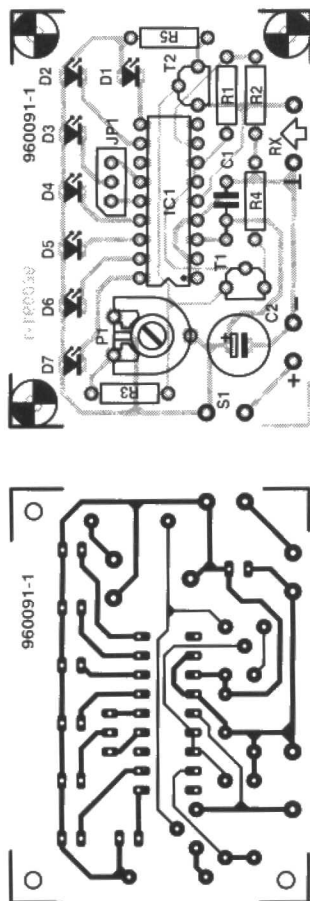
Figure 3. The printed-circuit board for the bulb tester is easily completed.

PARTS LIST

Resistors:
R_1 = 2.7 kΩ
R_2 = 1.8 kΩ
R_3, R_5 = 220 Ω
R_4 = 330 Ω
P_1 = 250 Ω preset

Capacitors:
C_1 = 100 nF
C_2 = 100 µF, 16 V, radial

Semiconductors:
D_1 = LED, red, low current
D_2–D_7 = LED, green, low current
T_1 = BC550C
T_2 = BC557B

Integrated circuits:
IC_1 = LM3915 (National Semiconductor)

Miscellaneous:
JP_1 = 3-way header and jumper
S_1 = single-pole press button switch
Bt_1 = 9 V battery (PP3, 6F22P, 6LR61)

Table 1.

Switching threshold (volt)	LED	test voltage (volt)	bulb wattage (watt)	filament resistance (Ω) (cold)
	D1	> 2.200		
2.2000				
	D2	1.680	15	336
1.5560				
	–	–	–	–
1.1025				
	–	–	–	–
0.7980				
	D3	0.750	25	150
0.5525				
	D4	0.475	40	95
0.3909				
	D5	0.2925	60	58.5
0.2765				
	D6	0.245	75	49
0.1961				
	D7	0.180	100	36
0.1382				
	–	–	–	–
0.0980				

rected by altering the value of R_2: a higher resistance results in a higher voltage.

When all is right, connect a multimeter set to the 10 mA d.c. range to terminals R_x and adjust P_1 until the meter reading is exactly 5 mA.

It is advisable to check the tester
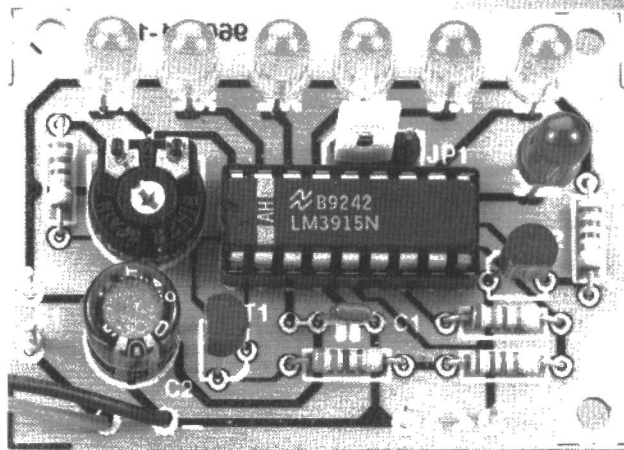
Figure 4. Photograph of the completed prototype board.

with a variety of known working electric bulbs and check that all relevant LEDs light as required. This is also the time to see what is the better position for JP_1. If the results are slightly adrift, they can almost certainly be corrected by adapting the test current slightly through a small readjustment of P_1.

Finally, although the test current is not large, it does heat up the filament of small-wattage bulbs quite quickly. It is, therefore, necessary to keep the test short to prevent a fault indication (red LED lights). [960091]

Figure 5. This wiring diagram enables all connections to be checked thoroughly.
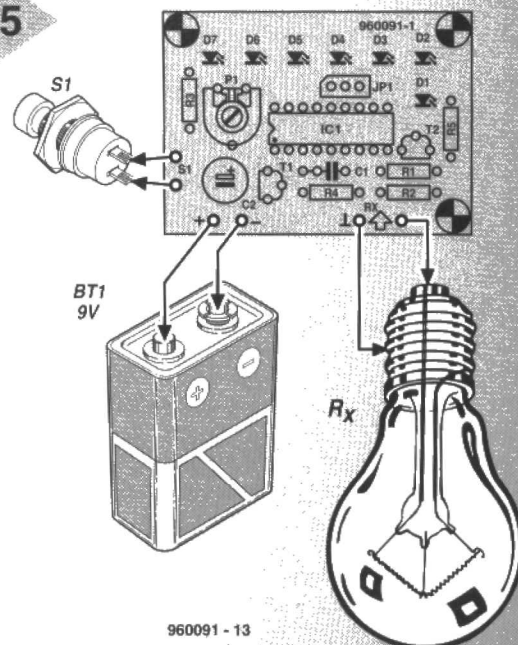
960091 - 13

focus on: software for circuit simulation

testing circuits without soldering

Computers are increasingly used to analyse electronic circuits. Today's simulation programs are so good that electronics designers can be 95% sure about the behaviour of almost any circuit, without having to make a single solder joint. Moreover, simulation is not limited to just the circuit diagram. Having designed the printed circuit board, for example, you may even run a simulation to check the effect of copper tracks on the board.

By our Editorial Staff
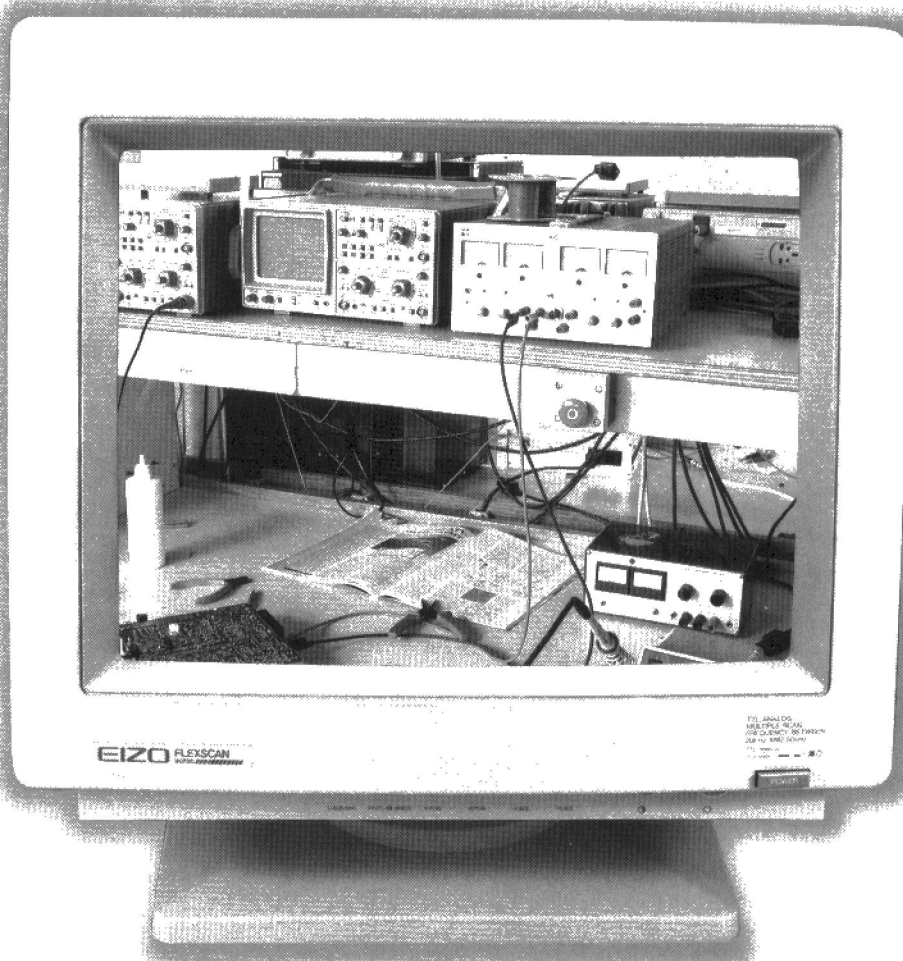
Simulating electronic circuits is not easy. Not surprisingly, it was just not practical before the arrival of large and (then) powerful computer systems. The first simulator to be developed in the sixties was called CANCER. It was soon followed by SPICE, designed at Berkeley University in the late sixties. SPICE2, a further development of SPICE, is generally considered to have caused a breakthrough in electronic circuit simulation. SPICE is an acronym for Simulation Program with Integrated Circuit Emphasis. The original SPICE programs have always been available free of charge for anyone. For an overview, see, among others, the Internet page www.paranoia.com/~filipg/html/faq/body/f_free_spice4.html. SPICE2, in turn, was used by a number of software companies as a basis for their own simulation programs. These were generally intended to be run on mainframes and, at a later stage, workstations. However, thanks to the growing popularity and computing power of the IBM-compatible PC, simulation programs started to appear for that platform, too, in the early 1980s. Meanwhile, these DOS programs (primitive as regards user interface) have been largely superseded by modern Windows versions, which has helped a lot as far as user friendliness is concerned. Moreover, the simulation abilities have been extended considerably, and the results are much more realistic than before.

Initially, electronics simulation programs were limited to simple components. Today, however, the models are very realistic indeed, while almost any step from design to production may be simulated.

MODELS AND NETLISTS

In principle, not much is required to simulate an electronic circuit. Essentially, all components are represented by resistors, inductors, capacitors, (driven) voltage and current sources, or combinations of these. Each junction in the circuit is numbered. Next, all this data is stored in a so-called netlist (**Figure 1**). This list indicates which component is connected between which junctions. In addition, the list also informs the system about the specific characteristics of the relevant component. The software then processes the list to set

up a number of current equations for these junctions. After solving the resulting equation matrix, the program knows all currents. Consequently, it is able to compute the voltages across all components in the design.

All this may look fairly easy, but a good simulation requires models which come as close as possible to the real-life behaviour of a component. **Figure 2**, for example, shows a simulation model of a diode (source: Interactive Image Technologies). In many cases, different models and modified or entirely different calculations are necessary for the direct voltage settings of the circuit, the alternating voltage response and the transient behaviour. This is illustrated in the example with the diode.

PSPICE AND CO.

The simulation algorithms and models applied in PSpice2 have been used as starting points by various software manufacturers for their own products. One of the best known programs in this area is PSPICE from Microsim, which appeared on the market in 1984. Many other, competitive, programs will have some indication or other reading 'PSpice compatible' or similar, which tells you that they are capable of processing or importing PSpice netlists.

Most simulation programs consist of a number of modules, each of which having a specific task. For example, there is usually an input model which allows the user to enter a circuit diagram (graphically, or as text), a calculation module which solves the network equations, and an oscilloscope program which presents the results graphically. In a program like PSpice, these modules are clearly separated, but there are also products like Micro-Cap which combine all these modules within a single shell.

SIMULATION OPTIONS

The simulation options are usually:
✗ **DC analysis**. This tells you how a circuit settles electrically after the power supply is switched on. In other words, you then know whether or not all active components are biased such that they function properly. The results enable you to draw conclusions about, say, the drive margin of a transistor stage or an opamp output.
✗ **AC analysis**. The alternating voltage behaviour of a circuit (in response to a sine wave) is computed at a number of frequencies to enable a Bode plot to be generated. The Bode plot shows the frequency and phase response, and, based on this data, the propagation delay of the hypothetical circuit. In many cases, a distinction is made between


```
*AMV
RO    GND      N00000                            1m
R1    N00004   N00002                            10K
R2    N00003   N00001                            10K
C1    N00002   N00001                            100N
C2    N00003   N00004                            200N
X1    GND      N00004   +5V   -5V   N00002   TL082/301/TI
X2    GND      N00001   +5V   -5V   N00003   TL082/301/TI
V1    +5V      GND                              5V
V2    GND      -5V                              5V
.LIB
.TRAN 10u 50m
```

Figure 1. Example of a netlist. Each line provides information on the type of component, the junctions it sits between, and then the specific properties of the component.

Figure 2. To be able to simulate an electronic component, you need a model which describes the real thing as closely as possible. The example shown here is the model of a diode: a) direct voltage model; b) alternating voltage model; c) transient model.
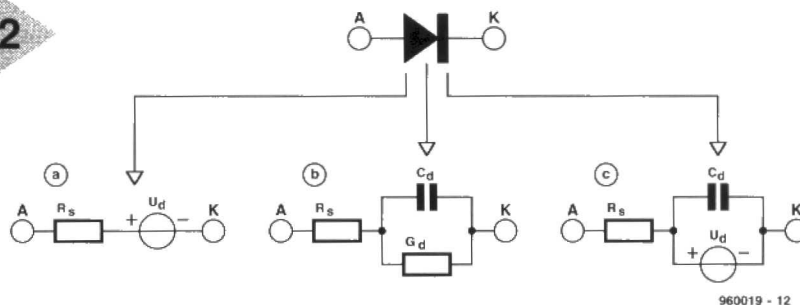
the a.c. response of a circuit to large and small signals.
✗ **Transient analysis**. This examines the way the circuit responds to certain signals the user is allowed to select (for example, a triangle waveform, a square wave, a staircase voltage). This method allows the response of the circuit to be traced in the time domain. With this type of analysis, the starting point is important: the user is allowed to select between a situation in which all d.c. settings are already present ('steady-state'), or a situation in which the power supply is not switched on until the starting instant. The latter option is particularly valuable to examine, for instance, the initial behaviour of an oscillator voltage after the supply is switched on.
✗ **Mixed-mode analysis**. Simulating digital and analogue components in a single circuit. Until a few years ago, separate programs existed to simulate analogue and digital circuits. With many up-to-date programs, these modes have been merged, which ensures greater flex-

ibility as far as entering circuit diagrams is concerned. It is possible to go further than just looking at the logic behaviour of a circuit. Because the models of digital components often include analogue properties, it becomes possible to examine timing errors and pulse rise times.
✗ **Fourier analysis**. Every waveform you can think of may be dissected into the sine wave components (basic frequencies) it consists of, which are presented along with their associated levels.
✗ **Monte Carlo analysis**. This is a statistical test in which a circuit is simulated many times in succession, while the component properties are modified in a random manner within tolerance bounds defined by the user. This test is particulary useful if you want to know how a circuit responds to tolerances which inevitably apply to the components used during the assembly phase. Usually, a Monte Carlo test may be run for d.c. as well as a.c. behaviour.
✗ **Parameter modifications, worst-case analysis, etc**. Basically, these are all related tests in which a com-

ponent value is 'shifted' step-by-step through its tolerance range (alternatively, only the tolerance bounds may be used). The analysis is started over again after any change in tolerance.
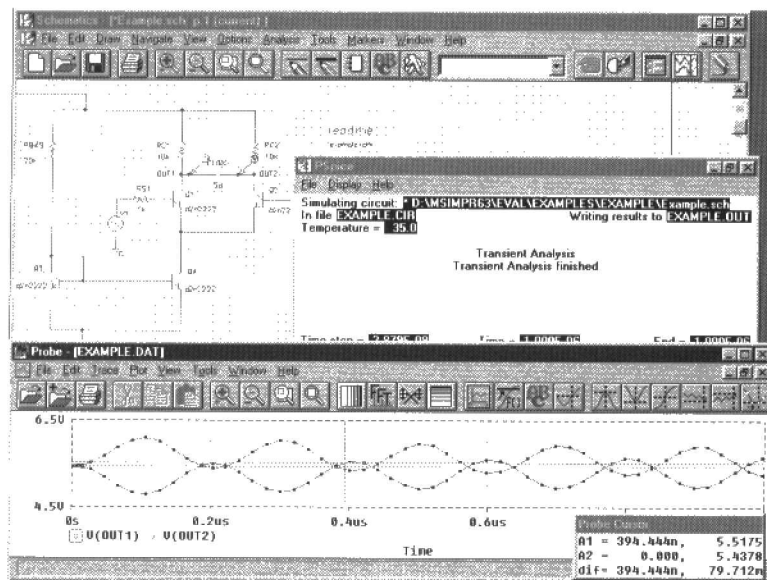
Although the options mentioned above may have different names in simulation programs, they do cover most, if not all, functions which are usually available.

Further important points for the user to concentrate on are: what is the size of the library which comes with the program; is it possible to add components easily, or modify the drawing symbols? Evidently, these points are more important to the professional user than to the hobbyist.

FROM LARGE TO SMALL

Broadly speaking, the simulation programs available today may be divided into three categories.

(Semi) professional programs

A range of programs is available for accurate simulation of extensive analogue/digital circuits. Here, we limit ourselves to versions which are intended to run on a PC. Well-known programs include PSpice A/D from Microsim, ICAP/4 from Intusoft, Smash Wizard from Dolphin Integration, MicroCap from Spectrum, and SpiceAge from Those Engineers. Complete versions of these programs may be expected to cost between £2,000 and £10,000. Auxiliary programs may often be obtained separately with these (semi) professional programs, for example, filter design tools, magnetic field simulators, and others.

Educational programs

Although educational programs are also complete simulation programs, it is still worthwhile to note that they differ from professional programs because of their structure or possibilities. Students in particular make fre-

quent use of simulation programs. The marketing aim is clear: many students of course start using professional programs once they have found employment.

The greatest simulation program we know for educational purposes is Electronics Workbench (v4.1) from Interactive Image Technologies (UK representative: Robinson Marshall). Using this program you have available a virtual multimeter, a signal generator, an oscilloscope, etc. These instruments appear on the screen, and may be hooked up to the circuit, just as in a 'real' lab, once the circuit diagram is complete. Beginners, too, will be able to use this program which is employed in many schools and educational institutions. Electronics Workbench, too, has been expanded and enhanced many times. As we write this, a mixed-mode 32-bit version is offered for which additional modules are available for Spice importing and exporting, model libraries and export facilities for printed circuit board layout programs. Recently, a competitive product appeared on the market: CircuitMaker from LabVolt. More details on this interesting new software product may be found on page 9 of the September 1996 issue of *Elektor Electronics*.

Not educational in the strict sense of the word, but also fitting in this category as far as price and potential buyers are concerned, are the so-called student versions of 'big' programs offered by various companies (including Intusoft and Spectrum). Usually, the maximum number of components and component junctions (nodes) is limited in the student versions. Normally, student packages are offered at reduced prices of between £40 and £80. For many electronics enthusiasts, such a student version is a good choice to become acquainted with electronic circuit simulation, and, of course, for actual work on those smaller circuits.

Hobby programs

Meanwhile, simulation programs have popped up in the shareware circuit, too. Such programs may be tried out during a limited period before you pay
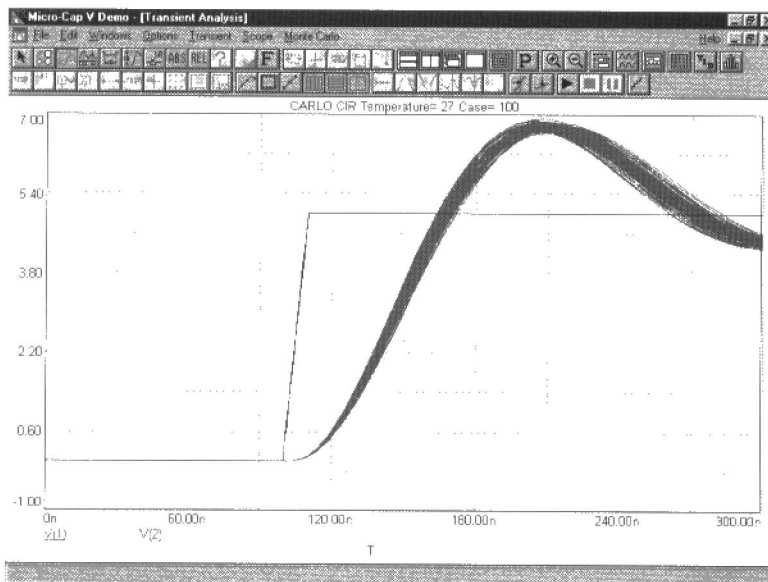
the author for his product. Simulation programs from the shareware circuit usually have a less professional look and feel than the ones mentioned so far, and also offer fewer simulation options. None the less, they are interesting enough to obtain some experience in this area. Moreover, the limited possibilities of the typical shareware program are a blessing for those who are easily confused by a multitude of options, preferences, files formats, etc. More is not always better!

Demonstration versions of a number of 'big-gun' programs are also available from their manufactures. These versions are often free of charge, and for evaluation purposes. Some are available on the Internet, for example, via www.intusoft.com and www.microsim.com. The demo version of PSpice, for instance (current version: 6.3), enables small circuits to be simulated and stored. In most demo versions, including that of MicroCap V, the 'save' and 'print' options are disabled, so that the user has to draw the circuit diagram from scratch every time the program is used. Be that as it may, such a simulation program is, of course, fine if you want to do a quick test on a small circuit, or just satisfy your curiosity.

FURTHER OUTLOOK

Future releases of the programs mentioned in this article will no doubt contain even better models, while the simulation methods will be improved. More important, however, is the trend which can be seen with EDA software (Electronic Design Automation), which aims at condensing the complete design process from circuit diagram to layout into one, continuous, operation. A few years ago we witnessed the amalgamation, so to speak, of analogue and digital simulation into a single program. Now, the software industry looks poised to include even the PCB layout phase in the design process. Not surprisingly, suppliers of simulation-only software, like Microsim, extend their product range in the direction of PCB design programs. Likewise, established makers of PCB design and schematic drawing programs are beginning to add simulation programs. OrCAD, for example, offers a simulation program for digital circuits, called OrCAD Simulate. Still others already supply a complete electronics design system, for example, the Proteus bundle from Labcenter Electronics. Note, however, that this package still consists of three modules.
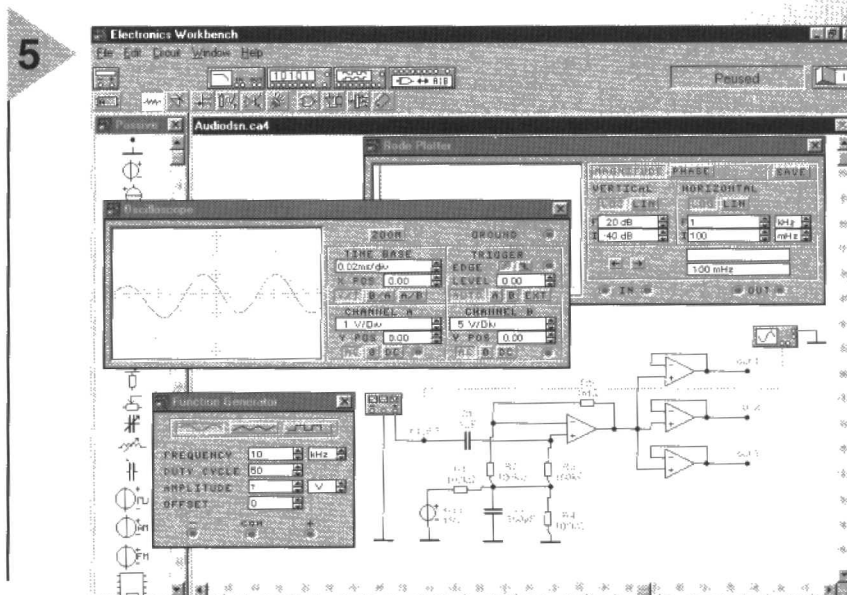
There are even programs around which are capable of simulating the effect of printed circuit board tracks. An example is the relatively new LAYAN software from Number One Systems.

In the near future, simulation programs will be so powerful and intelligent that users are able to see exactly how a circuit behaves on a certain board, check its unwanted emissions, and make sure that it complies with EMC directives.   (960019)

Next month we start a short course on simulation of analogue circuits called Hand On Electronics by Owen Bishop. The cases and examples discussed in this course may be applied in practice with the aid of a demonstration version of Micro-Cap V which may be obtained through your local distributor, or the Elektor Electronics Readers Services. Alternatively, you may use a similar Spice compatible simulation program.

---

dark-room timer

calibrated in f numbers

Although we would not denigrate the many photographic development and printing services (which vary from poor to fairly good), it is a fact that many serious amateur photographers would not dream of sending their carefully taken and exposed films to one of these bureaux. Many others are hesitant to do so. This article is aimed at all these photographers. It describes a dark-room timer that is calibrated in f numbers. This kind of calibration makes the timer much easier to use than the traditional ones that have a linear scale.
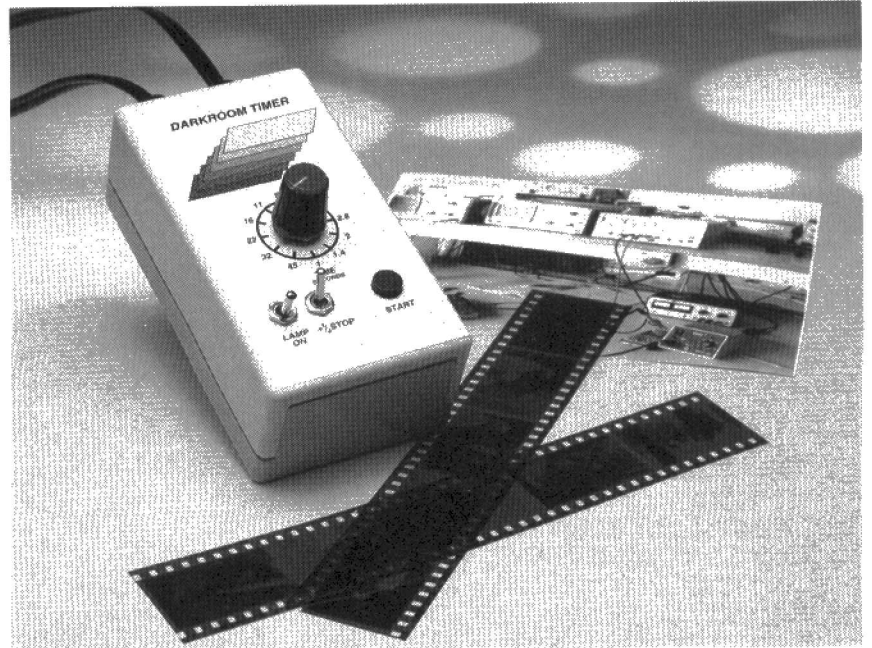
Single-lens reflex (SLR) cameras have an aperture ring (for setting the *f*-number) and a focusing ring. Anyone using such a camera will have noticed that the scales of these rings are graded so that the difference between two successive settings is always a factor 2. Selecting the next number down from a given stop means that twice as much light reaches the film, whereas the next number up means that the amount of light on the film is halved. Stops are also used on the enlarger in the dark-room, so that the objective aperture

The 555

The 555 can in truth be called the work-horse of electronics. It can be used in almost any case where an RC timer is required.

The IC can be used for building monostable as well as astable multivibrators for operation over a frequency range of 0–500 kHz.

There are CMOS versions of the IC: the 7555 or the newer TLC555.

Basically, the IC consists of a potential divider composed of three identical resistors, two comparators, a bistable (multivibrator), and an output buffer— see the block diagram.

When a negative trigger pulse of $<V_{cc}/3$ is applied to pin 2, timer capacitor C is discharged via an internal resistor. Subsequently, the capacitor is recharged via R_A. As soon as the potential across C has reach a value of $2V_{cc}/3$, the bistable is reset to its original state.

The width of the output pulse, T, is computed from

$$T = 1.1R_A C.$$

When the RC time has elapsed, the 555 is back in its original state, and the next period may begin.

Design by H. Valk

Brief parameters

Exposure time	calibrated in whole and half stops $+1/4$ stop
	$0–45$ seconds
Correction	12
Range	built in
Number of steps	built in
Lamp switch	300 W
Focusing facility	built in
Maximum power	
Power supply	

c a n always be set in neat, fixed steps, just like the *f*-numbers on a camera.

As far as the exposure timer is concerned, the situation is quite different, since this is often fitted with a linear scale. This makes choosing the correct exposure time rather tedious and may involve a lot of arithmetic. A stop higher means doubling the exposure time, so that if a proof print was exposed for one second, an extra stop requires a 2-second exposure. Similarly, an exposure time of 30 seconds must be increased to 60 seconds.

Note that when exposure times are long, the linear behaviour of the photographic paper becomes affected by the Schwarzschild effect. This normally requires additional correction of the exposure time. Altering this by half a stop becomes tedious, because the change is then not a factor 2 but a factor $\sqrt{2} = 1.414$. For this, you normally require a pocket calculator. And, of course, there is the difficulty that you are working in the dark. It stands to reason that many photographers need a timer that is calibrated in stops and half stops. The timer described in this article provides the possibility of correcting even by a quarter stop.

CIRCUIT DESCRIPTION

The circuit of the timer is shown in the diagram of **Figure 1**. In essence, it is based on the well-known Type NE555 chip. A section of the circuit provides the interface with the mains supply.

Most timers based on an NE555 use an *RC* network as the timing element. A detailed description of the operation of a monostable timer is given in the box on page 62.

As stated previously, the timer has 12 basic settings separated by a half stop. Switch S_1, resistors R_1–R_{12}, and capacitors C_1–C_2 form the timing element. Note that capacitor C_1 is the normally capacitance; C_2 only comes into operation when switch S_2 is closed. The additional capacitance en-

ables the gradation to be refined by an extra quarter of a stop. That is, when S_2 is closed, the exposure time is lengthened by a quarter of a stop. Users who see no need for this enhanced resolution may omit S_2 and C_2. Bear in mind that the basic range of 12 half-stop steps is more than adequate for virtually all applications.

The timer is actuated with switch S_3. As soon as this switch is closed, a negative trigger pulse appears at pin 2 of IC_1. The design of the input circuit ensures that the time the switch remains pressed does not affect the exposure time.

The output level at pin 3 (Q) goes high at the start of the mono time.

Figure 1. The circuit of the dark-room timer: the design has been kept as simple as possible.

The LED in solid-state relay IC_2 is powered via D_2 and R_{15}. As a result, the bulb in the magnifier is switched on. At the end of the mono time, the level at pin 3 goes low and the solid-state relay is deenergized. Consequently, the bulb in the magnifier is switched off.

Switch S_4 enables the bulb in the magnifier to be switched on and off independently of the timer circuit. When this switch is closed, the bulb is on so that the desired image can be assessed. The enlarger may be focused at the same time. When the switch is opened, the timer resumes control of the bulb in the enlarger.

The enlarger is connected to K_2, while the mains supply is linked to K_1.

The supply for the timer is perfectly straightforward: diode D_1 rectifies the secondary voltage of the transformer and the resulting pulsating voltage is smoothed by capacitor
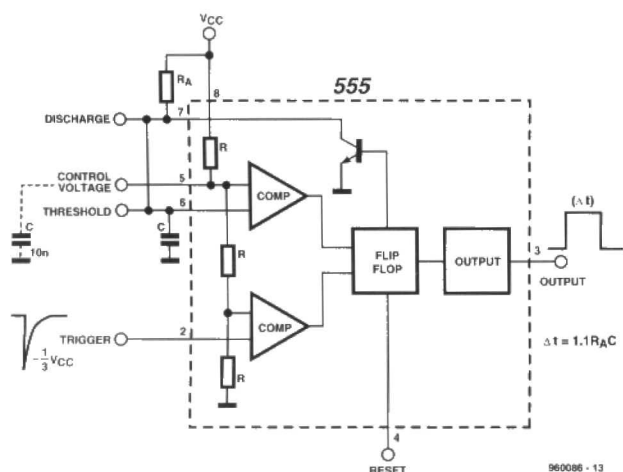
Switch position	Resistance selected	Total resistance	Time (seconds)
1	511 kΩ	511 kΩ	1.00
2	200 kΩ	711 kΩ	1.41
3	301 kΩ	1.012 MΩ	2.00
4	422 kΩ	1.434 MΩ	2.84
5	590 kΩ	2.024 MΩ	4.01
6	845 kΩ	2.869 MΩ	5.68
7	1.18 MΩ	4.049 MΩ	8.02
8	1.69 MΩ	5.739 MΩ	11.36
9	2.37 MΩ	8.109 MΩ	16.06
10	3.32 MΩ	11.429 MΩ	22.63
11	4.75 MΩ	16.179 MΩ	32.03
12	6.65 MΩ	22.829 MΩ	45.20

C_5. The consequent direct voltage is about 8 V.

DETERMINING THE TIMER STEPS

The value of the resistors in the timing element is calculated on the basis that the twelve timer steps differ by half a stop. Fortunately, the tolerance of the values is not very important: even when the optional facility of ¼ stops is used, it may be as high as 19 per cent without affecting the performance. The mono time, T, is calculated from

$$T = 1.1RC,$$
so that
$$R = T/1.1C.$$

Lengthening the exposure time by a ½ stop means that the time constant must be increased by $\sqrt{2}$ (≈ 1.414). Since the capacitor has a fixed value, all changes are brought about by selecting different value resistors. The resistors are combined into a series network, that is, every time a different resistor is selected, it changes the value of the resistor chain by $\sqrt{2}$. All resistors are from the E-96 series, not because of their low tolerance, but because the

parts
Parts list

Resistors:
R_1 = 511 kΩ
R_2 = 200 kΩ
R_3 = 301 kΩ
R_4 = 422 kΩ
R_5 = 590 kΩ
R_6 = 845 kΩ
R_7 = 1.18 MΩ
R_8 = 1.69 MΩ
R_9 = 2.37 MΩ
R_{10} = 3.32 MΩ
R_{11} = 4.75 MΩ
R_{12} = 6.65 MΩ
R_{13}, R_{14} = 100 kΩ
R_{15} = 300 Ω

Capacitors:
C_1 = 1 µF, 65 V, polystyrene (MKT)
C_2 = 330 nF
C_3, C_4 = 100 nF
C_5 = 100 µF, 25 V

Semiconductors:
D_1 = 1N4002
D_2 = 1N4148

Integrated circuits:
IC_1 = NE555 or TLC555
IC_2 = S202S02 or S201S04

Miscellaneous:
K_1, K_2 = 3-way terminal block, pitch 5 mm
S_1 = single-pole, 12-position rotary switch
S_2, S_4 = change-over switch for board mounting
S_3 = press-button switch with make contact
Tr_1 = mains transformer, 6 V, 350 mA
PCB Order no 960086-1
Enclosure
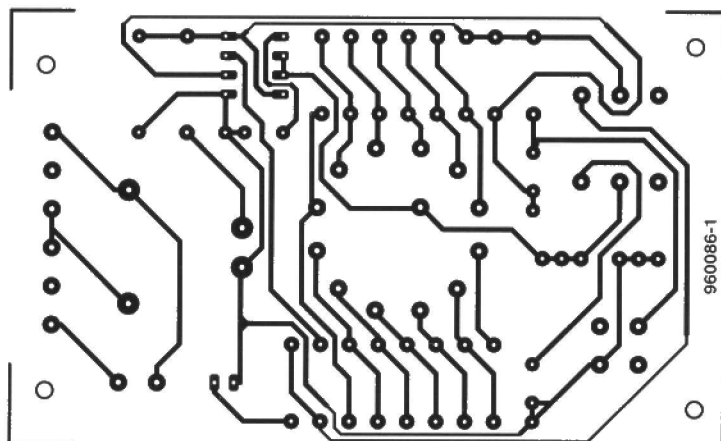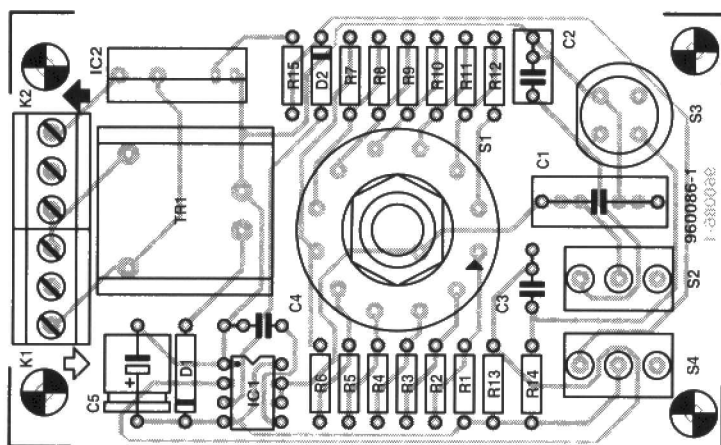
requisite values are best approached in this series. The correlation between the resistors is given in **Table 1**.

CONSTRUCTION

The timer is best built on the printed-circuit board shown in **Figure 2**. This is a very simple board that should not present any undue difficulties even to beginners in electronic construction. However, it is important to bear in mind that the timer is to be connected to the mains supply; this should be done only WHEN THE BOARD IS SAFELY FITTED IN A PLASTIC ENCLOSURE.

Rotary switch S_1 is fitted in the centre of the board. Make sure that its stop is set so that all 12 positions can really be used. If this is not so, the stop should be undone and reset as appropriate.

Switches S_2–S_4 are linked to the

Figure 2. The printed-circuit board for the dark-room timer.

Elektor Electronics 10/96

board via a number of solder pins that are mounted on the board first.

Mind the polarity of diode D_1 and capacitor C_5.

After the passive components, resistors, capacitors, connectors, and a socket for IC_1 have been put into place, fit IC_1 into its socket.

Next, fit IC_2 and transformer Tr_1 into place. Make sure that the terminals of IC_2 go as far as possible into the holes on the board, this ensures that the pins at which later the mains voltage is present cannot be touched.

Note that there are two versions of IC_2: the S201S02 and the S201S04. Only if the first is used, is series resistor R_{15} required. The optoisolator in the second version has this resistor already on board. In this case, R_{15} must be replaced by a wire bridge.

Figure 3. Photograph of the completed prototype.
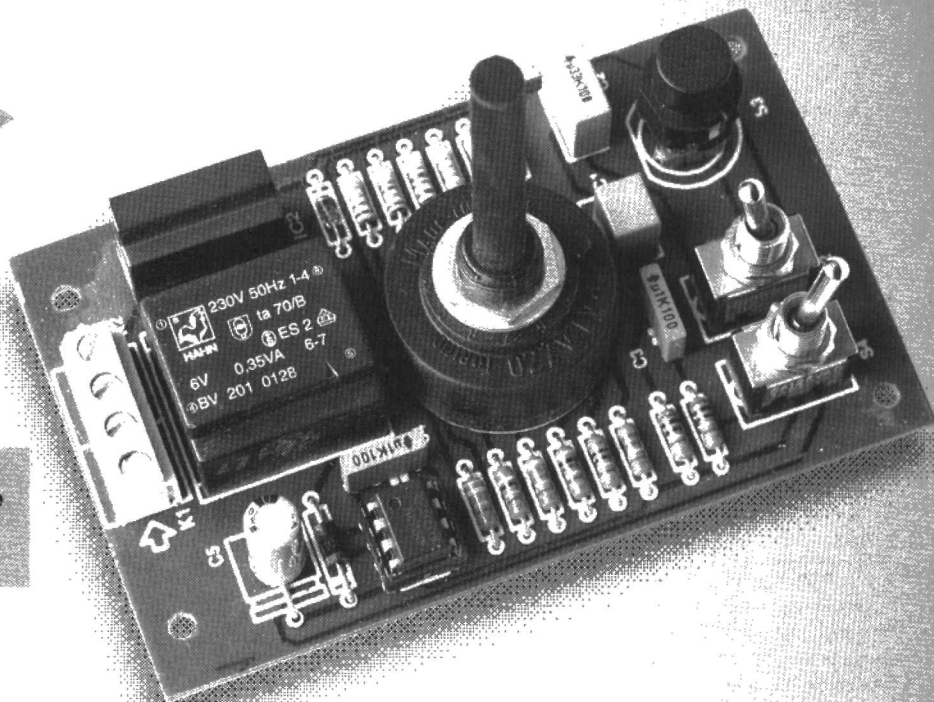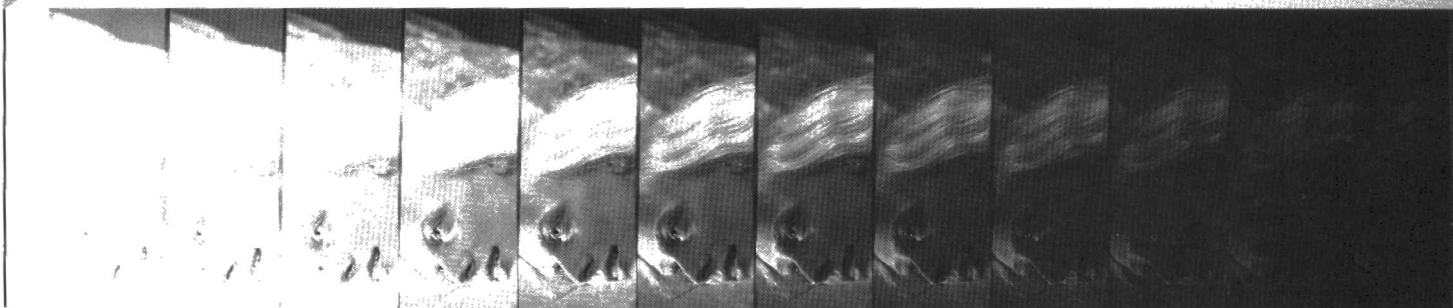
Figure 4. This proof strip clearly shows how the shading changes with successive ½ stop increases

FINALLY

When the board has been completed, it should be tested. Since mains voltage will be present at several locations, it is ABSOLUTELY ESSENTIAL that the board is fitted securely in a plastic enclosure.

Link the mains to K_1 via an appropriate length of mains cable, but do not switch the mains on yet. At the same time, connect a similar length of cable, terminated into an in-line socket, to K_2. Connect, say, a table lamp or similar to the in-line socket. A completed board is shown in **Figure 3**. Set S_1 to an exposure time of, say, 2 seconds.

Switch on the mains and check (with a stop watch, if possible; otherwise with a good standard watch) that the table lamp can be switched on for 2 seconds with S_3. Check all other settings one by one in a similar manner.

In the unlikely case that the circuit does not work properly, the cause for this can normally be found quite quickly with a multimeter.

First, make sure that a direct voltage of 8–10 V is present across C_5, and between pins 1 and 8 of IC_1. If this voltage is not present, the mains cable is faulty, the transformer does not work, or diode D_1 is faulty.

If the voltage across C_5 is correct, close S_4. If the table lamp does not come on, R_{15} or IC_2 is faulty.

If the lamp does light, check the timer circuit thoroughly. When S_3 is pressed, the level at pin 3 of IC_1 must be high for the time set. If this is so, and the table lamp still does not light, check diode D_2. If, however, the level at pin 3 does not go high, and the level at pin 2 of the IC is high in the quiescent state, it is almost certain that IC_1 is faulty and should be replaced.

When all is in working order, close the case. It is advisable to provide S_1 with a suitable scale such as, for instance, shown in **Figure 5**.

[960086]

Figure 5. Proposed scale for the exposure-time switch: calibration in whole stops and half stops.

DARKROOM TIMER

TIME SECONDS

LAMP ON   +¼ STOP   START
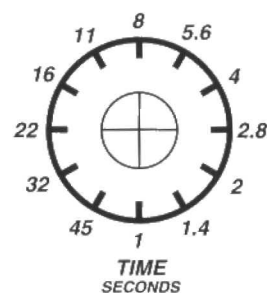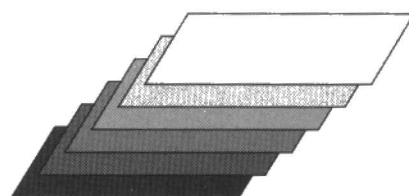
electronics on-line

test charts on the Internet

The publication of an advanced Video Test Chart Generator in this issue prompted us to search the Internet for test charts for TVs and computer monitors. Lo and behold, quite a few of these are easily found among the millions of web pages which are currently available on the net. Such test charts are ideal for adjusting and repairing computer monitors. By chance, we hit upon a virtual museum which shows a permanent collection of test charts from TV stations all over the world.

Although most of you will be totally aware of the fact that GIFF and TIFF pictures can not fully replace a real test chart, they are still useful for adjusting a computer monitor. One of the nicest programs around for testing your monitor is called MONTEST.EXE from Nokia (file size: 1.2 MB). It may be found on the Nokia Internet web site at www.nokia.com/products/monitors/monitor_test.html. The program may be downloaded from that page. The test program runs exclusively under Windows, and provides a number of useful (and accurate) test charts which enable virtually all relevant monitor settings to be checked.

Those of you who are looking for more generally applicable test charts should have a go at Chris' video test patterns page (address: www2.dgsys.com/~jchill/video). Chris has about ten test charts available in two resolutions: 6 4 0 ×480 pixels and 1024×768 pixels. On this page you find colour bars to the EIS and SMPTE standards, a number of screens, and an NTSC test chart. Any picture may be downloaded individually at the desired resolution.
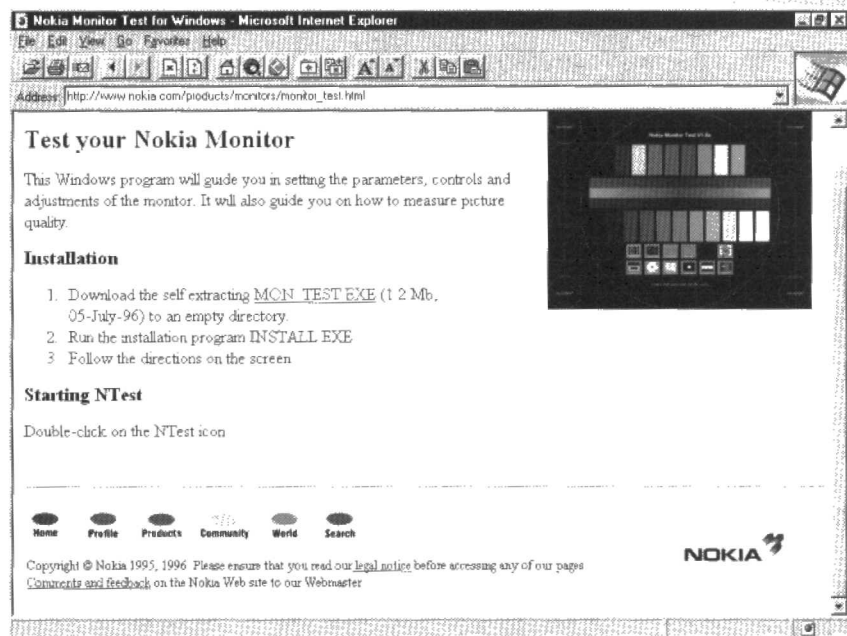
Another address that provides you with free test patterns is the 'Video Test Imagery' from Charles Henrich at the Michigan State University. The address is : wxweb.msu.edu/~henrich/video/. Charles has taken the trouble of composing three digital test charts which every web user is free to download from his site.

We close off this month's *Electronics On-line* page by pointing the way to a very special address: the TV Test Chart Museum. The address, www.ping.at/users/stay-tuned/program.html takes you to the 'Stay Tuned' page which offers a number of test options ranging from sounds to short films. One of these, at the left-hand side of the page, leads you to the 'testbild museum' (test chart museum), a cluster of four virtual rooms (rooms 1, 2, 3 and 4) in which tens of test charts are on display from TV stations all over the world. Full-screen versions of most of these test charts are available. Looking around in these 'rooms' is certainly worthwhile.
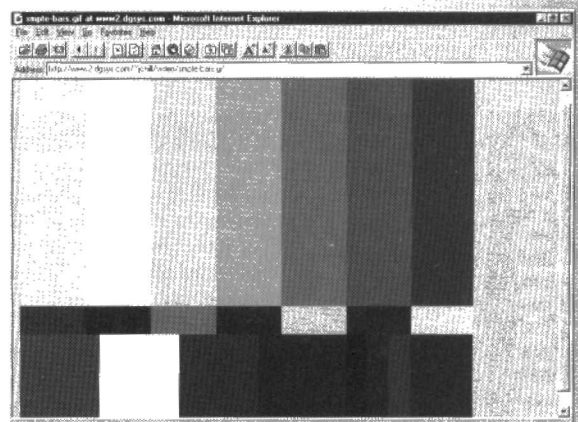
(965096)
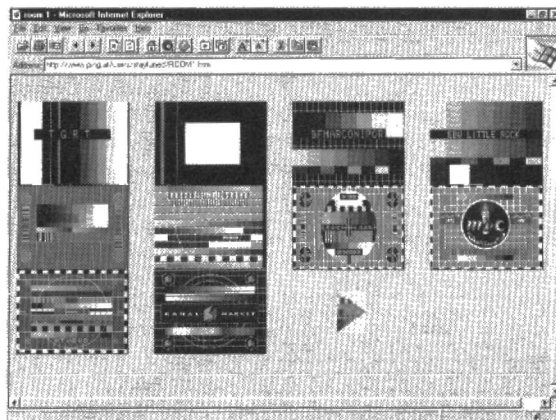
READERS SERVICES

ELEKTOR ELECTRONICS
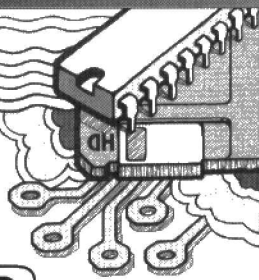
OCTOBER 1996

GENERAL

Ready-made printed-circuit boards (PCBs), self-adhesive front panel foils, ROMs, EPROMs, PALs, GALs, microcontrollers and diskettes for projects which have appeared in *Elektor Electronics* may be ordered using the order form printed opposite. The form may also be used to order books (private customers only).

» Items marked with a dot (●) following the product number are in limited supply only, and their availability can not be guaranteed by the time your order is received.

» Items not listed here should be ordered.

» The artwork for making PCBs which are not available ready-made through the Readers Services may be found in the relevant article.

» EPROMs, GALs, PALs, (E)PLDs, PICs and other microcontrollers are supplied ready-programmed.

Prices and item descriptions subject to change. The publishers reserve the right to change prices without prior notification.

Prices and item descriptions shown here supersede those in previous issues. E. & O.E.

ORDERING INSTRUCTIONS, P&P CHARGES

Except in the USA and Canada, all orders, except for subscriptions and past issues (for which see below), must be sent BY POST to our Dorchester office using the Order Form opposite. Please note that we can not deal with PERSONAL CALLERS, as no stock is carried at the editorial and administrative office.

Readers in the USA and Canada should send orders, except for subscriptions (for which see below), to Old Colony Sound Lab, Peterborough NH, whose full address is given on the order form opposite. Please include shipping cost according to total order value. For surface delivery in the USA, if order is less than $50, include $3: $50+. $4. For Canada surface, if less than US$50, include US$5: US$50+, US$7.50. For air or other deliveries, please inquire. Please allow 4-6 weeks for delivery.

All other customers must add postage and packing charges for orders up to £25.00 as follows: UK and Eire £2.10; surface mail outside UK £2.60; Europe (airmail) £3.10; outside Europe (airmail) £3.85. For orders over £25.00, but not exceeding £100.00, these p&p charges should be doubled. For orders over £100.00 in value, p&p charges will be advised.

HOW TO PAY

Unless you have an approved credit account with us, all orders must be accompanied by the full payment, including postage and packing charges as stated above.

Payment may be made by cheque **drawn on a London clearing bank** (but see para. 4 below), postal order, VISA, Access, MasterCard or EuroCard (when paying by credit card, the order must give the cardholder's address). Do not send cash through the mail. Cheques and postal orders should be crossed and made payable to 'Elektor Electronics (Publishing)'.

Payment may also be made by direct transfer from a private or business Giro account to our **Giro account No. 34 152 3801** by completing and sending to the National Giro Centre, in a National Giro postage paid envelope, a National Giro transfer/deposit form. Do not send Giro transfers direct to us, as this will delay your order.

If you live outside the UK, payment may also be made by Bankers' sterling draft **drawn on a London clearing bank**, **Eurocheque** made out in pounds sterling (with holder's guarantee card number written on the back), or US or Canadian dollar cheque drawn on a US or Canadian bank.

If you pay by Bankers' sterling draft, make clear to the issuing bank that your full name and address MUST be communicated to the London clearing bank.

Our bankers are **National Westminster Bank, 49 South Street, DORCHESTER, Dorset DT1 1DW, England.** Our account number is **6966 3340**.

SUBSCRIPTIONS & PAST ISSUES

Subscriptions and past issues, if available, should be ordered from **Worldwide Subscription Service Ltd, Unit 4, Gibbs Reed Farm, Pashley Road, TICEHURST TN5 7HE, England, telephone (+44) 1580 200657, fax (+44) 1580 200616.**

Prices of past issues (except July/August and December), including postage for single copies, are £3.20 (UK and Eire); £3.50 (surface mail outside UK); £3.75 (air mail Europe); £4.50 (airmail outside Europe). Prices of past July/August and December issues, including postage for single copies, are £4.25 (UK); £4.50 (surface mail outside UK); £4.75 (airmail Europe); and £5.50 (airmail outside Europe).

PAST ARTICLES

For information on past articles, please contact our Editorial and Administrative Office in Dorchester (telephone 01305 250995; fax 01305 250996).

COMPONENTS

Components for projects appearing in *Elektor Electronics* are usually available from appropriate advertisers in this magazine. If difficulties in the supply of components are envisaged, a source will normally be advised in the article. It should be noted that the source(s) given is (are) not exclusive — other suppliers may also be able to help.

TERMS OF BUSINESS

Delivery Although every effort will be made to dispatch your order within 2-3 weeks from receipt of your instructions, we can not guarantee this time scale for all orders.

Returns Faulty goods or goods sent in error may be returned for replacement or correction, but not before obtaining our consent. All goods returned should be packed securely in a padded bag or box, enclosing a covering letter stating the dispatch note number. If the goods are returned because of a mistake on our part, we will refund the return postage. Goods returned for refund must be in resaleable condition and will be subject to a 10% handling charge with a minimum charge of £2.50.

Damaged goods Claims for damaged goods must be received at our Dorchester office within 10 days (UK); 14 days (Europe) or 21 days (all other countries) from the date on our 'Recorded delivery' slip.

Cancelled orders All cancelled orders will be subject to a 10% handling charge with a minimum charge of £2.50.

Patents Patent protection may exist in respect of circuits, devices, components, and so on, described in our books and magazines. Elektor Electronics (Publishing) do not accept responsibility or liability for failing to identify such patent or other protection.

Copyright All drawings, photographs, articles, printed circuit boards, programmed integrated circuits, diskettes and software carriers published in our books and magazines (other than third-party advertisements) are copyright and may not be reproduced or transmitted in any form or by any means, including photocopying and recording, in whole or in part, without the prior written permission of Elektor Electronics (Publishing) in writing. Such written permission must also be obtained before any part of these publications is stored in a retrieval system of any nature.

Notwithstanding the above, printed-circuit boards may be produced for private and personal use without prior permission.

Limitation of liability Elektor Electronics (Publishing) shall not be liable in contract, tort, or otherwise, for any loss or damage suffered by the purchaser whatsoever or howsoever arising out of, or in connexion with, the supply of goods or services by Elektor Electronics (Publishing) other than to supply goods as described or, at the option of Elektor Electronics (Publishing), to refund the purchaser any money paid in respect of the goods.

Law Any question relating to the supply of goods and services by Elektor Electronics (Publishing) shall be determined in all respects by the laws of England.

July 1996

Article title	Order no.	Price (£)	(US$)
OCTOBER 1996			
Video Test Chart Generator:			
- PCB, EPLD, EPROM and disk	960076-C	79.50	159.00
- EPLD EPM7032	966507-1	39.00	78.00
- EPROM 27C040	966507-2	24.50	49.00
- disk	966011-1	7.00	14.00
Mini Metal Detector	960075-1	5.50	11.00
Darkroom Timer	960086-1	11.75	23.50
Sampling Rate Converter:			
- PCB and ST62T10	960093-C	28.75	57.50
- ST62T10 (IC2)	966511-1	19.50	39.00
Thrifty Crystal Oven	960071-1	12.75	25.50
Electric-Bulb Tester	960091-1	6.00	12.00
Multi-Purpose Pascal I/O Unit (disk only)	966013-1	7.00	14.00
SEPTEMBER 1996			
Digital max/min thermometer:			
- PCB and ST62T10	960010-C	27.75	55.50
- ST62T10 (IC1)	966515-1	19.50	39.00
Standby Unit for TV Economy	960063-1	12.00	24.00
Digital Compass	960085-1	7.50	15.00
RS232 Interface for A/D Converter ICL7106:			
- software on disk	966016-1	6.00	12.00
JULY/AUGUST 1996			
Solar-Charging Regulator	930096	8.25	16.50
Continuity Tester	UPBS-1	1.95	3.90
Symmetrical Power Supply	UPBS-1	1.95	3.90
Harmonic Distortion Meter	936024-1	5.50	11.00
Sound-to-Light Unit	950123-1	9.50	19.00
50-MHz dBm Meter	964039-1	16.50	33.00
Precision Battery Capacity Meter	964040-1	8.00	16.00
Video Fader	964076-1	12.25	24.50
Inexpensive AD/DA Converter:			
- PCB	964092-1	Not Available	
- software on disk	966009-1	7.00	14.00
Single-Chip AF Power Amp	964104-1	6.25	12.50
JUNE 1996			
Flash EPROM Programmer/Emulator			
- PCB + disk	960077-C	33.00	66.00
- disk only	966017-1	16.00	32.00
Keyboard Swap for PCs	950126-1	7.00	14.00
Stop that Barking!	960035-1	5.50	11.00
23cm ATV preamplifier	960072-1	7.50	15.00
Pulsimeter	960005-1	10.25	20.50
Burglar Deterrent Lighting	960022-1	7.25	14.50
MAY 1996			
Intelligent Chess Clock:			
- PCB + 87C51 (946645-1)	950097-C	41.75	83.50
- 87C51	946645-1	30.75	61.50
Digital VU meter (2):			
- PCB + EPROM (946646-1)	950098-C	36.00	72.00
- EPROM 27C512	946646-1	17.75	35.50
Surround Sound Subwoofer (3):			
- PCB	960049-1	16.75	33.50
Mains Voltage Monitor:			
- PCB	960055-1	7.25	14.50
64-Channel Logic Analyser:			
- main PCB, disk & IC4,IC5	960033-C	69.75	139.50
- IC4 ispLSI1016	966506-1	27.50	55.00
- IC5 ispLSI1016	966506-2	27.50	55.00
- disk (MSDOS)	966010-1	7.00	14.00
- extension PCBs (3-in-1)	960033-2	17.00	34.00
- IC20/30/40 ispLSI1016	966506-2	27.50	55.00
APRIL 1996			
U2402B Battery Charger	950120-1	12.00	24.00
Centronics Interface:			
- PCB + disk (966008-1)	960052-C	16.25	32.50
- Disk (Windows)	966008-1	6.00	12.00
PC-Controlled AF Analyser (2):			
- Software on disk	966001-1	26.00	52.00
MARCH 1996			
Houseplant Buzzer (4 on 1 board)	950118-1	10.00	20.00
PIC-Controlled RDS Decoder:			
- PCB + PIC (966505-1)	960050-C	27.50	55.00
- PIC 16C84	966505-1	22.75	45.50
FEBRUARY 1996			
SIMM tester:			
- PCB + EPROM (966503-1)	960039-C	28.25	56.50
- EPROM	966503-1	10.25	20.50
I²C Interface for Centronics port:			
- PCB + disk (946202-1)	950063-C	20.25	40.50
- control software on disk	946202-1	12.25	24.50
Passive VU meter	950124-1	8.00	16.00
FM Receiver in SMT	936049	5.00	10.00
Icy Roads Warning	960029-1	6.00	12.00
JANUARY 1996			
SECAM-to-PAL Converter	950078-2	29.00	58.00
Copybit Inverter:			
- PCB + MACH/GAL	950104-C	44.00	88.00
- MACH/GAL	956513-1	35.25	70.50
Passive Component Tester			
- PCB	960032-1	13.75	27.50
- Front panel foil		Not available	
DECEMBER 1995			
3.3-15V Power Supply	950106-1	9.25	18.50
Practice Amplifier for Guitars	950016-1	17.25	34.50
Smart Transistor Tester:			
- PCB + PIC (956502-1)	950114-C	44.25	88.50
- PIC 16C71	956502-1	35.50	71.00
Micro PLC System:			
- PCB + 87C750/51 + disk	950093-C	44.50	89.00

Article title	Order no.	Price (£)	(US$)
- 87C750/51	956514-1	24.50	49.00
- control software on disk	956016-1	10.00	20.00
Active potentiometer	954099-1	9.50	19.00
Descaler	954080-1	5.75	11.50
Active probe	954093-1	8.00	16.00
Two-way PC-Fax Interface	954033	11.75	23.50
NOVEMBER 1995			
PIP Processor:			
- PCB + 87C51 (956505-1)	950078-C	54.75	109.50
- 87C51	956505-1	30.75	61.50
FM noise squelch	950089-1	10.75	21.50
PA 300 power amplifier	950092-1	19.75	39.50
Jogging LED	950112-1	7.00	14.00
Oscilloscope prescaler	950115-1	27.75	55.50
OCTOBER 1995			
MatchBox BASIC computer:			
- PCB, 87C51, disk and Quick Reference Card	950011-C	59.25	118.50
- 87C51	956508-1	43.50	87.00
- Course diskette (DOS)	956009-1	11.50	23.00
- Quick Reference Card	950011-P	3.25	6.50
Special Autumn Supplement:			
- Experimentation board for PICs, incl. free disk for *PLC Emulator Using PIC Micro-controllers*	944105-1	17.75	35.50
SEPTEMBER 1995			
Hi-fi headphone amplifier	950064-1	5.00	10.00
Dongle safe:			
- PCB	950069-1	12.75	25.50
- GAL IC2 (20V8)	956511-1	10.00	20.00
- GAL IC6 (22V10)	956512-1	11.75	23.50
HexFET power amp upgrade:			
- amplifier PCB	930102	12.75	25.50
- power-on delay PCB	924055	6.45	12.90
Copybit eliminator update:			
- PCB + MACH (956504-1)	950084-C	40.50	81.00
- MACH IC	956504-1	36.50	73.00
RF tone-dip oscillator	950095-1	5.25	10.50
JULY/AUGUST 1995			
Active mini subwoofer	938047	12.25	24.50
Mini robot car	936069	8.00	16.00
Simple RF function generator	950023-1	7.50	15.00
Alkali/Manganese battery charger	950056-1	6.75	13.50
Fast charger for NiCd batteries:			
- PCB + ST62T20 (956509-1)	950076-C	22.75	45.50
- ST62T20	956509-1	14.75	29.50
Simple I/O card	954074-1	11.50	23.00
6-V motive battery charger	940083-1	7.25	14.50
JUNE 1995			
Function generator:			
- PCB	950068-1	29.50	59.00
- Front panel foil	950068-F	17.75	35.50
Electronic sandglass:			
- PCB + 87C751 (946647-1)	950052-C	26.25	52.50
- 87C751	946647-1	17.75	35.50
Auto light control	950050-1	4.75	9.50
VGA distribution amplifier	950017-1	10.00	20.00
MAY 1995			
MIDI analyser:			
- PCB + EPROM (956507-1)	940020-C	34.25	68.50
- EPROM	956507-1	16.75	33.50
Programmer for 87/89C51 series Flash controllers:			
- PCB + EPROM (956644-1)	950003-C	26.50	53.00
- EPROM	946644-1	14.50	29.00
Programmable sine wave generator:			
- PCB + disk (956005-1)	950004-C	19.50	39.00
- control software on disk	956005-1	12.25	24.50
NiCd battery-quality tester:			
- PCB + ST62T15 (956506-1)	950051-C	25.25	50.50
- ST62T15	956506-1	18.25	36.50
APRIL 1995			
Electronic barometer	936033	8.50	17.00
Bat detector	936046	10.25	20.50
Sun blind control	950035-1	9.25	18.50
Function generator:			
- PCB + front panel foil	950044-C	21.75	43.50
- PCB	950044-1	11.00	22.00
- Front panel foil	950044-F	12.50	25.00
Stepper motor control:			
- PCB + 8751 + disk	950038-C	50.75	101.50
- 8751	956503-1	35.25	70.50

Elektor Electronics books

	(£)	(US$)
How to build your own Electronic Test Instruments	£15.95	$29.50
How to build your own AF valve amplifiers	£14.95	$28.00
Short course 8051/8032 Microcontrollers and Assembler	£9.95	$18.50
SMT projects	£9.95	$18.50
301 Circuits	£9.95	$18.50
302 Circuits	£9.95	$18.50
303 Circuits	£10.95	$20.25
304 Circuits	£12.95	$23.95
305 Circuits	£14.95	$27.70
Microprocessor Data Book	£10.95	$20.25
Data Sheet Book 2	£9.95	$18.50
Data Book 3: Peripheral Chips	£10.95	$20.25
Data Book 4: Peripheral Chips	£10.95	$20.25

ORDER FORM

Please send this order form to *
Elektor Electronics (Publishing)
P.O. Box 1414
Dorchester DT2 8YH
ENGLAND
Tel. (01305) 250995
Fax (01305) 250996

*USA and Canada residents only: use $ prices, and send order form to:
Old Colony Sound Lab, P.O. Box 243, Peterborough, NH 03458.
Tel. (603) 924-6371. 924-6526. Fax: (603) 924-9467

Name	
Address	
	Post code
Tel.	Fax	Date

Please supply the following. For PCBs, front panel foils, EPROMs, PALs, GALs, microcontrollers and diskettes, state the part number and description; for books, state the full title; for photocopies of articles, state full name of article and month and year of publication. Please use block capitals.

Qty.	Order Code	Description	Price each	Total
	CD-ROM Elektor 1995.	See pages 46 and 47. Normal price: £41.00 (US$65.00). Reduced price for subscribers*: £37.00 (US$58.50).		

Method of payment (see opposite before ticking as appropriate)
Note: cheques not made out in sterling must be increased by the equivalent of £15.00

❏ Bank draft   ❏ Cheque (payable to Elektor Electronics Publishing)

❏ Giro transfer (our account no. 34 152 3801)

❏ Postal/money order

❏ VISA   Access   MasterCard   E EUROCARD

Prices and item descriptions subject to change. The publishers reserve the right to change prices without prior notification. Prices and item descriptions shown here supersede those in previous issues. E. & O.E.

Sub-total
P&P
Total paid

Expiry date: _____   * Subscription number: _____

Signature: _____

Article title	Order no.	Price (£) (US$)
- test program on PC disk	956004-2	3.75 7.50
MARCH 1995		
Telephone-controlled mains switch:		
- PCB + PIC (946642-1)	950010-C	22.00 44.00
- PIC 16C54	946642-1	17.50 35.00
DSP function generator:		
- PCB + disk (956001-1) +		
EPROM (956501-1)	950014-C	49.00 98.00
- EPROM 27C512	956501-1	13.25 26.50
- software on IBM PC disk	956001-1	18.50 37.00
- Windows program manual	950014-P	7.50 15.00
TDA1560Q car audio		
amplifier	950024-1	9.50 19.00
FEBRUARY 1995		
MIDI multiplexor	930101	15.00 30.00
Automatic lighting timer	940098-1	10.75 21.50
Infrared dimmer	940109-1	9.75 19.50
Light-effects generator	940100-1	6.50 13.00
Upgrade your car battery		
charger	940111-1	7.00 14.00
Surround sound processor	950012-1	18.75 37.50
Induction motor governor	940095-1	7.50 15.00
JANUARY 1995		
Mini Audio DAC	940099-1	14.75 29.50
1-to-3-phase converter:		
- PCB + GAL + EPROM	940077-C	52.75 105.50
- GAL	946640-1	12.25 24.40
- EPROM	946640-2	15.75 31.50
P.O.S.T. diagnostic card:		
- PCB + GALs (946639-1/2)	950008-C	29.25 58.50
- GAL-1	946639-1	11.00 22.00
- GAL-2	946639-2	13.00 26.00
Self-loading EEPROM type		
X88C64 SLIC	940116-1	8.25 16.50
Debugging 8031/8051		
microcontroller systems:		
- PCB + disk (946203-1)	940117-C	15.00 30.00
- software on IBM PC disk	946203-1	11.50 23.00
DECEMBER 1994		
In-car audio amplifier (3)	940078-2	30.25 60.50
RF immune power supply	940054-1	9.00 18.00
ispStarter kit from Lattice:		
- PCB + disk (946204-1)	940093-C	21.50 43.00
- Examples on PC disk	946204-1	9.75 19.50
NOVEMBER 1994		
Single-wire communication	940055-1	4.00 8.00
In-car audio amplifier (2)	940078-2	30.25 60.50

Article title	Order no.	Price (£) (US$)
Solid-state disk:		
- PCB + EPROM (946641-1)	940085-C	47.50 95.00
- EPROM 27256	946641-1	23.50 47.00
Simple capacitance meter	940091-1	10.00 20.00
OCTOBER 1994		
Motive-battery charger	940083-1	7.25 14.50
Integrated AF amplifier:		
- output amplifier board	936062-1	9.50 19.00
- preamplifier PCB	936062-2	28.25 56.50
Tester for IR remote control	940084-1	6.50 13.00
In-car audio amplifier (1)	940078-1	14.00 28.00
TV line monitor:		
- PCB + PIC (946643-1)	940065-C	26.25 52.50
- PIC 16C54	946643-1	20.25 40.50
SEPTEMBER 1994		
Switchable a.c. supply	934004	6.50 13.00
Compact frequency meter	940051-1	9.00 18.00
Revolution counter:		
- sensor board (option)	940045-1	6.00 12.00
- main board	940068-1	5.50 11.00
JULY/AUGUST 1994		
General purpose IR volume		
control	930099	9.00 18.00
IR controlled switch	936066	9.75 19.50
MIDI swell pedal:		
- PCB + EPROM (946635-1)	940019-C	26.75 53.50
- EPROM 27C64	946635-1	13.75 27.50
Charge meter	940033-1	5.75 11.50
Joystick-to-mouse adaptor	944040-1	7.00 14.00
Centronics I/O interface	944067-1	8.75 17.50
80C451 controller board	944069-1	15.00 30.00
Robust AF power amp	944075-1	9.75 19.50
PC over-temperature alarm	944076-1	4.25 8.50
1-4 MByte SIMM adaptor	944094-1	15.50 31.00
Optical doorbell	944080-1	6.25 12.50
PIC experimenting board	944105-1	17.75 35.50
RC5 transmitter with 80C535:		
- PCB + disk (946199-1)	944106-C	13.00 26.00
- software on IBM PC disk	946199-1	9.75 19.50
Small loop antennas:		
- software on IBM PC disk	1951	10.75 21.50
Software emulation of RC5		
infra-red code:		
- software on IBM PC disk	1901	10.75 21.50
PIC programming course:		
- files and misc. utilities on		
IBM PC disk	946196-1	9.75 19.50
JUNE 1994		

Article title	Order no.	Price (£) (US$)
80C535 SBC extension:		
- software on IBM PC disk	1941	9.75 19.50
- I²C display software on		
IBM PC disk	946197-1	9.75 19.50
I²C bus booster	940057-1	7.25 14.50
RS485 interface	940035-1	6.25 12.50
Fuel consumption monitor	940045-1	6.00 12.00
Intelligent EPROM eraser	940058-1	9.00 18.00
MAY 1994		
Mains signalling system - 2:		
- transmitter PCB, disk (1911)		
and EPROM (6371)	940021-2C	33.25 66.50
- EPROM 27C64	6371	13.25 26.50
- software on IBM PC disk	1911	9.75 19.50
APRIL 1994		
Mains signalling system - 1:		
- receiver board	940021-1	10.25 20.50
68HC11 processor board	930123	7.75 15.50
Headphones amplifier	940016	18.75 37.50
MARCH 1994		
80C535 assembler course:		
- EMON52 ROM + disk (1811)	6221	17.05 34.10
- disk (IBM PC format)	1811	8.80 17.60
100W AF amplifier		
- adaptor board	930039	8.25 16.50
FEBRUARY 1994		
80C535 single-board		
computer	924046	14.10 28.20
Copybit eliminator:		
- PCB + MACH + GAL	930098-C●	46.25 92.50
- MACH + GAL	6321	42.25 84.50
Mini preamplifier	930106	29.25 58.50
Bidirectional RS232-to-		
Centronics converter	930134	14.00 28.00
JANUARY 1994		
SIM — an 8051 simulator:		
- software on IBM PC disk	1931	34.25 68.50
Digital dial	920161	12.75 25.50
RDS decoder:		
- PCB + EPROM (6331)	930121-C	23.75 51.50
- EPROM 27C64	6331	14.50 29.00
I²C tester:		
- PCB + GAL (6341)	930128-C	36.25 72.50
- GAL type 6001	6341	30.75 61.50
Telephone-controlled switch:		
- EPROM 2764	6271	14.50 29.00

Elektor Electronics slipcase

Price: £2.95 + P&P (£1.50 UK; £2.00 outside UK)

Article title	Order no.	Price (£) (US$)
DECEMBER 1993		
535 card with EPROM emulator:		
- GAL and PAL	6311	26.00 52.00
RMS AF voltmeter:		
- PCB	930108	12.25 24.50
- front panel foil	930108-F	17.25 34.50
I²C power switch	930091	6.25 12.50
Medium power HEXFET		
amplifier	930102	12.75 25.50
Microcontroller-driven UART:		
- PCB	930073	4.75 9.50
- ST62T10	7151	17.25 34.50
SCART switching box	930122	14.25 28.50
NOVEMBER 1993		
Precision clock for PCs:		
- PCB + disk (1871)	930058-C	12.25 24.50
- software on IBM Pc disk	1871	8.50 17.00
VHF/UHF TV tuner		
- PCBs -1 and -2, and		
μC 87C51 (7141)	930064-C	57.25 114.50
- μC 87C51	7141	25.75 51.50
Output amplifier with AF		
bandpass filter	930071	6.75 13.50
Digital hygrometer:		
- PCB + EPROM (6301)	930104-C	28.00 56.00
- EPROM 2764	6301	14.50 29.00
Power MOSFET tester	930107	32.50 65.00
OCTOBER 1993		
Stereo mixer	UPBS-1	1.95 3.90
MIDI channel monitor	930059	14.00 28.00
Ah meter with digital display	930068	14.00 28.00

Article title	Order no.	Price (£)	(US$)
Autoranging frequency readout	930034	12.50	25.00
ROM-gate switchover for Atari ST	930005	30.25	60.50
Microntroller-driven NiCd battery charger			
- board and ST62E15	920162-C	25.50	51.00
- ST62E15	7071	10.00	20.00
Fuzzy logic multimeter - 2:			
- PCB + Fuzzy Control One	920049-C	23.75	47.50
- Fuzzy Control One disk	1721	7.75	15.50
SEPTEMBER 1993			
Fuzzy logic multimeter -1	920049-2	20.00	40.00
Linear temperature gauge	920150	7.05	14.10
PC-aided transistor tester:			
- PCB	920144	9.75	19.50
- software on IBM PC disk	1781	7.50	15.00
Harmonic enhancer	930025	13.50	27.00
I2C alphanumerical display:			
- PCB + disk (1851)	930044-C	14.25	28.50
- Software on IBM PC disk	1851	8.50	17.00
Mini micro clock			
- PCB	930055	7.50	15.00
- clock: ST62T15	7111	11.50	23.00
- darkroom timer: ST62T15	7121	11.50	23.00
- cooking timer: ST62T15	7131	11.50	23.00
950-1750 MHz converter	UPBS-1	1.95	3.90
JULY/AUGUST 1993			
Active 3-way loudspeaker system	930016	21.50	43.00
Maxi micro clock			
- PCB	930020	15.50	31.00
- clock: ST62T10	7081	11.50	23.00
- darkroom timer: ST62T10	7091	11.50	23.00
- cooking timer: ST62T10	7101	11.50	23.00
SMD soldering station	930065	9.50	19.00
VHF-low converter	926087	15.50	31.00
I2C bus fuse (5 on 1 PCB)	934016	8.00	16.00
Voice operated recording	934039	6.00	12.00
General transformer PCB	934004	6.50	13.00
Plant humidity monitor	934031	4.50	9.00
Plant humidity monitor (supply)	934032	4.00	8.00
Four-fold DAC card for PCs:			
- GAL	6251	10.75	21.50
Multi-purpose display decoder:			
- EPROM 27128	6261	11.50	23.00
JUNE 1993			
Spectrum VU meter	920151	13.00	26.00

Article title	Order no.	Price (£)	(US$)
GAL programmer upgrade:			
- PCB	930060	4.50	9.00
- software on IBM PC disks	1701	11.15	22.30
- idem, w/o Opal Jr. disks	1881	10.75	21.50
- software on Amiga disk	1841	11.00	22.00
Digital frequency readout for VHF/UHF receiver	926001-2	11.50	23.00
Inexpensive phase meter:			
- main board	930046	9.00	18.00
- meter board	920018	4.70	9.40
- front panel foil	930046-F	17.25	34.50
X2404-to-8751 interfacing:			
- software on IBM PC disk	1891	8.50	17.00
MAY 1993			
FM stereo signal generator	920155	23.00	46.00
Philips preamplifier:			
- PCB	930003	7.50	15.00
- software on IBM PC disk	1861	8.50	17.00
APRIL 1993			
Audio power meter	930018 ●	10.25	20.50
Video digitizer for PCs:			
- PCB + disk (1831)	930007-C ●	37.00	74.00
- Software on IBM PC disk	1831	14.50	29.00
Infrared receiver for 80C32 single-board computer:			
- PCB and disk (1791)	920149-C ●	14.50	29.00
- software on IBM PC disk, also for DTMF decoder	1791	7.50	15.00
4MB printer buffer card:			
- PCB	920009 ●	27.50	55.00
- EPROM 27C64	6041	15.30	30.60
- front panel foil	920009-F ●	8.25	16.50
MARCH 1993			
Linear sound pressure meter	930006 ●	7.00	14.00
Electrically isolated RS232 interface	920138 ●	10.25	20.50
TV test pattern generator for 8032 SBC:			
- EPROM 27256	6151	15.30	30.60
FEBRUARY 1993			
Digital audio/visual system (4):			
- software package, EPROM, GALs and IBM PC disk	6181	30.50	61.00
U2400B NiCd battery charger:			
- PCB	920098 ●	8.75	17.50
- front panel foil	920098-F ●	8.75	17.50
Digital-audio enhancer	920169 ●	14.25	28.50
I2C opto/relay card:			

Article title	Order no.	Price (£)	(US$)
- PCB	930004 ●	11.00	22.00
- software on IBM PC disk	1821	7.65	15.30
Watt-hour meter:			
- PCBs -1 and -2, and EPROM (6241)	920148-C ●	37.25	74.50
- EPROM 27256	6241	10.00	20.00
DECEMBER 1992			
1.2 GHz multifunction frequency meter:			
- PCB + EPROM (6141)	920095-C ●	29.40	58.80
- EPROM 27C256	6141	11.45	22.90
- front panel foil	920095-F ●	13.80	27.60
Output amplifier for ribbon loudspeakers	920135-1 ●	19.40	38.80
	920135-2 ●	7.95	15.90
Peak-delta NiCd charger	920147 ●	4.10	8.20
Mains power-on delay	924055 ●	6.45	12.90
NOVEMBER 1992			
Difference thermometer	920078 ●	5.30	10.60
Low-power TTL-to-RS232 interface	920127 ●	3.55	7.10
OCTOBER 1992			
Wideband active antenna	924101 ●	3.25	6.50
RDS demodulator	880209 ●	5.30	10.60
Pascal routines for Multi-function Measurement Card for PCs: software on disk	1751	9.70	19.40
SEPTEMBER 1992			
EPROM emulator - II:			
- PCB	910082 ●	10.00	20.00
- Software on IBM PC disk	129	6.75	13.50
JULY 1992			
12VDC to 240VAC inverter			
- main board	920039-1 ●	11.15	22.30
- power board	920039-2 ●	6.45	12.90
- front panel foil	920038-F ●	16.15	32.30
JUNE 1992			
I2C display	920004 ●	4.70	9.40
Guitar tuner:			
- PCB	920033 ●	10.00	20.00
- front panel foil	920033-F ●	8.80	17.60
Multi-purpose Z80 card	920002 ●	20.25	40.50
- GAL set (2x16V8)	6111	11.15	22.30
- BIOS EPROM 27128	6121	15.30	30.60
- software on IBM PC disk	1711	7.65	15.30

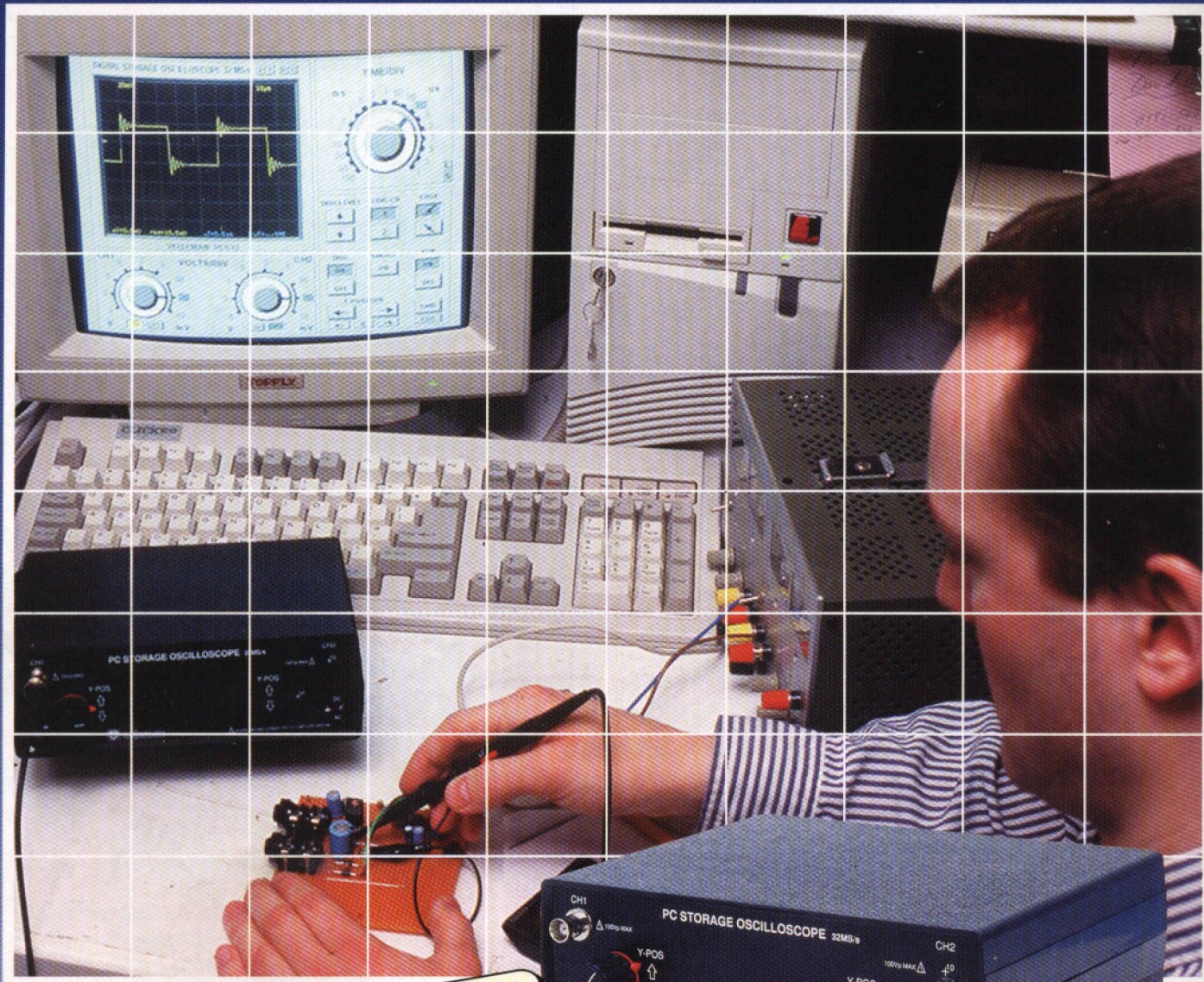| Article title	Order no.	Price (£)	(US$)
May 1992			
GAL programmer:			
- PCB	920030 ●	11.15	22.30
- software see June 1993			
APRIL 1992			
80C32 SBC extension	910109 ●	13.50	27.00
2-metre FM receiver	910134 ●	10.30	20.60
Automatic NiCd charger	UPBS-1	1.95	3.90
LCD for L-C meter	920018 ●	4.70	9.40
MARCH 1992			
8751 emulator	920019 ●	12.05	24.10
- EPROM 27C64 + IBM disk	6051	29.40	58.80
A-D/D-A and I/O for I2C bus:			
- PCB	910131-2 ●	6.15	12.30
- software on IBM PC disk	1821	7.65	15.30
FEBRUARY 1992			
I2C interface for PCs	910131-1 ●	14.40	28.80
8051/8032 assembler course:			
- EMON51 EPROM + course disk for IBM PCs (1661)	6061	20.00	40.00
- EMON51 EPROM + course disk for Atari (1681)	6091	20.00	40.00
- course disk for IBM PCs	1661	7.65	15.30
- course disk for Atari	1681	7.65	15.30
JANUARY 1992			
Mini Z80 system	910060 ●	10.60	21.20
Prototyping board for IBM PCs	910049 ●	21.15	42.30
PC-controlled weather station (3)			
- software on IBM PC disk (supersedes 1551 and 1561)	1641	7.65	15.30
DECEMBER 1991			
Class-A power amplifier (2):			
- protection PCB	880092-3 ●	7.50	15.00
- power supply PCB	880092-4 ●	7.60	15.20
Connect-4 software in 2764 EPROM	6081	15.30	30.60
NOVEMBER 1991			
Relay card for universal I/O interface	910038 ●	12.95	25.90

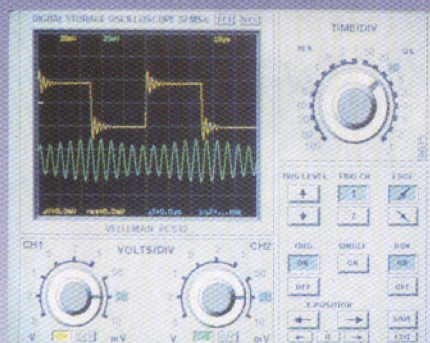Availability of older items is advised by our Dorchester Office, tel. (01305) 250995, fax (01305) 250996.